THE

ART OF SPINNING

AND

THREAD MAKING,

WITH

CALCULATIONS AND TABLES

FOR THE USE OF THE

CARDING AND SPINNING MASTER.

BY

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PREFACE.

THIS Volume has been written principally for those connected with spinning and thread making, and I am satisfied it will be of great use to them. It will also be interesting and instructive to the general reader, as the different processes are explained in the most simple manner; beginning with the raw material, and carried on up to the finished thread ready for the market.

I have thought it best to give a brief and connected account of the whole subject in one place, leaving the details, and all the calculations for the different machines, to be given under their respective heads. The principles upon which the calculations are made are explained, and a number of these are fully wrought out. There are also a number of tables which will save the time of the carding and spinning masters. In the last chapter instructions are given how to manage the steam boilers and engines.

When I was learning the spinning trade, I should have been very glad to have had an opportunity of reading any treatise on spinning, but at that time there were none to be had. Now there are several bearing less or more upon the subject. I have endeavoured to supply what is lacking in those that have been published, more especially in the art of thread making.

September, 1878.

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FORM OF COTTON STORE BOOK.

Date.	No. of Bale.	Mark.	Description.	Gross Weight.		Real Weight.		Tare.		Difference.		
				Lbs.	Oz.	Lbs.	Oz.	Lbs.	Oz.	Lbs.	Oz.	

FORM OF PICKING HOUSE BOOK.

Date.	Description.	No. of Bale.	Put Through.		Clean Cotton.		Willow Drops		Sand, &c.		Remarks.
			Lbs.	Oz.	Lbs.	Oz.	Lbs.	Oz.	Lbs.	Oz.	

FORM OF MIXTURE BOOK.

Date.		Description.	Weight.	Private Mark.	Total Weight.	Cost. £	s.	d.	Remarks.

THE

ART OF SPINNING

AND

THREAD MAKING.

CHAPTER I.

COTTON AND ITS CULTIVATION.

Some remarks about cotton, and the history of cotton spinning, will be given before the theory of the art is proceeded with, as these may assist the reader to understand better some of the statements that it will be requisite to make concerning cotton spinning; besides being interesting to those that are not acquainted with the subject.

The English word *cotton*, is the name given to the soft vegetable down, or fibrous substance, which is contained in the seeds, vessels, and envelopes the seeds of the cotton plant. The term *cotton* is taken from the Arabic name *khuton*, written by the Italians *cotone*. The name given to the cotton plant is *gossypium*, which is the Latin word for *cotton*. According to botanists, there is a number of different varieties of the cotton plant, and we know there is a great variety in the quality of the wool. The plants are principally

cultivated in the East and West Indies, North and South America, China, Egypt, and a number of other places; but at the present time (1877) the great bulk of the cotton, that is cultivated for commercial purposes, is cultivated in the Southern States of the American Union.

The plant from which the cotton is got is natural to many places, and grows without cultivation in Egypt, Arabia, India, China, and some other places; and the fibrous substance would be seen by the inhabitants of these countries, and, if they were acquainted with twisting the fibres of the flax plant into thread, the idea would be readily suggested to them that this fibre might be twisted into thread also, as a similar idea has occurred to many a cotton spinner, when walking in some of the uncultivated fields in Scotland, where the thistles were in full blow, with their fine white down. He would pull a little, and try the length and strength of the fibre, then conclude that this down of the thistle could be spun into yarn with the same machinery that is used for spinning cotton.

So, in like manner, the native inhabitants of those parts of the earth where the cotton plant grew wild, would, after they had found out the use of the cotton for dress, &c., turn their attention to the cultivation of the plant. But the mode they had in those early times of preparing the ground, and of planting the

seed, there is no record to tell us. Further on we find that the ground was prepared much in the same manner as for other plants: by loosening the soil and putting in the seeds in holes a considerable space apart from each other, both in length and breadth, and the spaces left between the plants were kept free from weeds and grass, by digging and hoeing as required; and when cotton came to be an article in great demand, more attention was paid to its cultivation, and consequently, many improvements one after the other were introduced. The spade to a considerable extent was superseded by the plough, and a better mode of husbandry was begun.

The field is all turned up by the plough, and formed into ridges, varying in width according to the kind of plant, and are about four, five, six, or eight feet wide, and elevated in the centre. When the ground is flat, and liable to contain too much moisture, drains are made between the ridges to carry off the superfluous water into a main ditch or drain, which is made across the field. When the soil has been all properly prepared, a groove or furrow is made in the top of the ridge, with an implement, (which is made for the purpose) from two to four inches deep; the depth of this furrow or groove is made to suit the kind of soil, and the state of the weather, at the time of sowing. After the furrow is made the seeds of the cotton plant are deposited in it

—either by hand or by a machine—very similar to the sowing of turnip seed, but very much thinner. Still, a considerable quantity of seed is put in, compared with the plants that are to be grown, as it has been found that there is no economy in being sparing with the seeds. Another implement is used for covering up the seeds, and it is adjusted so as to give the requisite amount of pressure to the earth, which amount of pressure is regulated according to the quantity of moisture that is in the soil at the time. There is another machine that would save a large amount of labour and seed by being introduced (if not introduced already) for the sowing of the seeds. The cotton plants require a space of one or two feet between them when they are full grown; and, instead of putting in a quantity of seeds all along the furrow, this machine puts a sufficient quantity at intervals of every one or two feet, according to the distance that may be required for the different kinds of plants. The exact distance is measured by the machine after it has been properly set. The machine for sowing is similar in construction to that for the digging of potatoes; but, instead of the arms for digging up the potatoes, there is an endless chain with a small oblong cup or filler attached to it. This cup or filler is made so as to contain the proper quantity of seed to be deposited in one place. Although one plant is all that is wanted to be cultivated, yet it is necessary to

put in a considerable number of seeds for the one plant, for the purpose of securing germination. Within a week of the seeds being sown, the plants begin to make their appearance, if the weather is favourable; and about four or five weeks after the sowing, the plants should be four or five inches above the ground, and if they are that length, the first thinning may begin, when only the weakest plants are taken out. As the plants increase in strength, the thinning continues at intervals, according to circumstances, until they are all taken out but the one that is to bear the cotton. At each of these thinnings, the ground is cleared of weeds and grass; and, after the plant has grown to the height of twenty or twenty-four inches, the tops of the twigs are taken off, for the purpose of making it grow bushier, as they thus blossom better than when allowed to grow tall and slender. When the plants have attained a certain height, the earth is well drawn over the roots and up the stalks, to support them against the storm.

From the time of the sowing of the seeds, until the picking of the cotton (which is about three or four months) from the pods commences, the cotton plant is in danger of being partially or wholly destroyed from various causes. At the beginning of the season, the frost, or very strong north winds, may render as useless all the previous labour spent on the sowing of the seeds; and even if the plants survive until they

are very well advanced, they are liable to be damaged by small insects, known by various names. I suppose that those insects must be of the moth or caterpillar species, for when they attack the plants they eat up all the leaves, and otherwise injure the plants to such an extent that, in some seasons, almost whole fields are destroyed by their ravages. Various expedients have been resorted to for the purpose of preventing the damage done by these little creatures, but as yet, a thorough cure for the evil has not been found out.

When the blossoms fade and fall off, there is a small nut, fully larger than the hip of a wild rose, left, and it increases in size until it is about one and a quarter inch in diameter; and when ripe, it opens, and displays the cotton, and then the first pickings begin; and the pickings continue sometimes three and four months, the length of time depending upon the season, and how the pods appear. There is sufficient space between the rows of bushes, for the workpeople that gather the cotton from the pods, to pass up and down without injuring the bushes. Each of the workers has a bag for the purpose of putting the cotton and seeds in as they pluck it from the pods, the bag being tied to the person, so that the worker may have the use of both hands for picking. When the bag is full it is emptied into a basket large enough to contain a day's picking of one worker, so that, when the day's picking is over, it is known how much each person

has done, the cotton and seeds being weighed when taken to the storehouse in the evening. These remarks that we have made apply to the annual plant, and the other kinds will be taken notice of further on, after we have given a description of how the cotton is treated.

After the cotton is gathered into the store, it is, as soon as the weather permits, dried by spreading it on a platform made for the purpose, and exposing it to the rays of the sun. When it is perfectly dry, it is removed from the platform, into a place where it is to be put through a process, which separates the seeds from the cotton. There is a certain amount of dampness in the seed cotton when taken from the bush, therefore, it is usual to have it completely dry before the operation of ginning begins, both for the purpose of preventing it from heating, and for making it part more easily from the seeds.

The original gin is a very simple machine, being a pair of rollers fitted up in a wooden frame, and capable of being made to revolve either by the foot or by the hand. The rollers are made very small in diameter, being less than three quarters of an inch, consequently must be made short to keep them from bending, their length being from six to nine inches. The reason for having them so small in diameter is, that the seeds of the cotton are small, not so large as common peas, and they would be apt to be drawn in

with the cotton if the rollers were larger in diameter; so the less they are in diameter the better, if they have strength just sufficient to keep them from yielding. The cotton, with seeds still fixed to the fibres, is placed upon a board or shelf in front of the rollers, and the worker pushing it towards the revolving rollers, the fibres are taken hold of and passed through between the rollers, and the seeds separated from the cotton. This operation is called *ginning*, and the cotton is afterwards carefully picked and the sand shaken out of it, either by a machine or by switching it with the hand. But it is only the higher priced cotton that will repay the planter putting it through this process of picking and ginning with the common rollers.

The low priced cotton is, in general, separated from the seeds by a machine known by the name "Whitney's Saw Gin." It is said that when the saw gin was really made perfect, and brought into use, it caused quite a revolution in the mode of treating the cotton in America, and that one man could do as much with the new machine as eighty or ninety could do with the old one. Be this as it may, it is evident from the construction of the two machines, that the saw gin machine has the superiority of producing a much larger quantity, in a given time, than the common roller gin; because the very nature of the roller machine prevents it from being increased in size:

whereas, the make of the saw gin machine does not limit the machine maker to any particular size.

The principal parts of the "saw gin machine" consist of one cylinder keyed on to a malleable iron shaft. This cylinder may be made seven or eight inches in diameter, and the length of it will be according to the number of serated plates that are to be put on it. These serated plates are similar in appearance to rims of small circular saws, and are from three to four inches larger in diameter than the cylinder, the hole in the centre of the plate being the same size as the diameter of the cylinder. An iron washer and one of the serated plates are put on the cylinder alternately, the thickness of the iron washer regulating the distance of the plates from each other, which distance is determined by the spaces of an iron grating which is part of the machine. The distance from the centre of one space to the centre of the other should be less than three quarters of an inch. There is another malleable iron shaft with three, four, five, or six cast-iron rings keyed on it, the number of rings being less or more in proportion to the length of the saw cylinder, as the one is made exactly the same length as the other, and this is called the brush shaft. If the serated plates be twelve inches in diameter, the cast iron rings, on the brush shaft, are made twenty-one inches. These rings are similar to belt pulleys, with the arms cast all to the one side, for the purpose of getting the brush

straps screwed down to the flange of the rings with small bolts. Six or eight brush straps are fixed on the rings, separated from one another at regular distances, this is necessary for the purpose of making it act partly as a fan; for, if it were made like a common cylinder brush, it would not cause a current of air. The saw shaft, and the brush shaft, are placed in the machine on the same horizontal plain, and parallel to each other. The saw shaft at the front of the machine, right behind the iron grating, which grating is made with a curvature of one fourth of a circle corresponding to the diameter of the saws, the edges of the saws enter the spaces of the grating, and project through at the curvature about half-an-inch. In front of this part of the grating is a box for receiving the seed cotton, similar to a hopper into which corn is put for the purpose of being ground at the mill. When the seed cotton is put into the hopper, the teeth of the saws take hold of the fibres of the cotton, and pull it through the grating into the inside of the machine; and, the spaces of the grating being smaller than the seeds, these are not taken through, but, being freed from the wool, fall to the bottom of the hopper, in which there is an opening for the purpose of allowing the seeds to drop into a place outside the machine. The brush shaft being placed at the back of the saw shaft, and revolving at a greater speed than the saws, it brushes off the

cotton from the teeth of the saws, and throws it down on an iron plate, which is perforated with small holes, to allow dust or sand to fall through.

The feeding of the machine is either done by the worker putting in a certain quantity into the hopper at intervals, or it is fed regularly by a self-acting apparatus, driven by the same power that drives the machine, which is a steam engine, water wheel, or horse power. Some use a fan for drawing off the dust that comes from the cotton when it is being ginned.

At first, when the saw gin machine was introduced, the saws were made in two half circles, and fixed on a wooden beam instead of an iron cylinder, small grooves being turned in the beam, where the saw plates were inserted. The principle of the present machines is the same as those that were made at first, although they have been greatly improved in the details.

The planters, who are particular about the picking of the cotton, have it all examined, both before it is ginned and afterwards by the workers, who pick out all the pieces of cotton that are considered bad, and any other extraneous matter that may be mixed with it; but there are some who do not pay so much attention as they should to the picking, as I have got bales, in which the quantity of seeds and sand that were mixed up with the cotton, were more than one-fifth of the whole weight. When this is the case, it

causes a great deal of annoyance, both to the cotton broker and the spinner, and is a loss in the end to the planter.

The old mode of bagging the cotton was as follows: There is a hole, about thirty inches in diameter, made in the floor of the flat where the cotton is lying to be bagged. The empty bag is suspended right below this hole. The mouth of the bag, being firmly fixed round the edges of the hole, one of the workers gets inside the bag, and, when the cotton is supplied, it is pressed down by the feet of the person in the bag, and also beat down with a round iron ball attached to a wooden handle. This is continued, layer after layer, until the desired quantity is put into the bag, which is then sewed up at the mouth, and marked with its distinctive mark and number, and put aside for delivery. In the places where cotton is grown to any extent for exportation, the bales are made up in a press, to which is applied either screw or hydraulic power; and the bales are held together in their small dimensions by iron hoops or ropes, and are in this state exported. By being packed in this manner, the cost for the carriage is much less per lb., than when the cotton is put up in loose bags; and it is less liable to be damaged by water when hard pressed, than when it is loose in the bags.

The previous remarks upon cotton have been principally about the annual plant, and we will now take

notice of a few varieties. For a long time, brokers and cotton spinners formed their opinion, upon the value of the article, from the name of the place from which the cotton came, and to a certain extent, they do so still; but the real value of it is found upon examination, because, from the same place, many different qualities of cotton bearing the same name, are sent. For instance, some sea island cotton, from the same country, will have qualities so varied, that the top market price will be sometimes double the lowest, and varying between the two extremes; so that the true value is to be found in the length, the fineness, and strength of the staple, taking into consideration the colour, and the way it has been packed, as regards seeds, sand, and other things that may be mixed with the cotton.

SEA ISLAND COTTON.

This is the name given to that fine cotton, principally grown in Georgia, South Carolina, but also in some other places. The name is derived from the circumstance of the plants thriving best on the small islands near the sea shore. The coast of Georgia, for four or five miles inland, is a salt marsh. In front of this, towards the sea, there is a chain of islands of grey rich soil, covered in the natural state with pine, oak, hickory, and other kinds of wood; and it is on these

places that the sea island cotton is cultivated. The names of these islands are, Tyhee, Warsaw, St. Catherine's, St. Simon's, Cumberland, and a few others. The land bordering on the salt marsh is of nearly the same quality as that of the islands. The rivers and creeks are bordered with swamps or marsh, which, at every tide, for a number of miles from the coast, are either wholly or partially overflowed—these constitute the rice plantations, but, when drained and cultivated, makes the best soil for the cotton plants. Indeed, it seems that the fine long stapled cotton requires to be grown near the sea shore, as the same seeds sown inland deteriorate in proportion to the distance from the sea. As its nearness to the sea makes the crop more uncertain, by being more exposed to the inclemency of the weather, the planter cannot calculate upon the return for his labour and outlay with the same degree of certainty as the inland planter can do. Hence, the price must always be higher. There is not the least doubt, that if a larger profit could be made by growing the long staple cotton, than what can be made by cultivating the short staple kind, a much larger quantity of it would be brought forward by the planters. The impression that some people have got, that the fine long staple cotton is only suitable for fine yarns, is an erroneous one; for, if it was low in price, the very lowest numbers could be spun from it, and it makes better

yarn than the short staple cottons do, even in coarse numbers. But the very *fine numbers* can only be spun from the fine long staple cotton. The plant would grow to the height of twelve or fifteen feet, and last for a number of years, if it were allowed, but it has been found better to plant every year. The colour of the sea island cotton is often like cream, but sometimes it is pure white. The amount of labour required to bring forward a thousand pounds of sea island cotton, ready for shipment, is very much greater than what is necessary for the same quantity of the upland cotton. The pods of the short staple in general open nearly about the same time, whereas, the pods of the long staple open at several intervals, which causes a longer time to be spent in gathering, as it has to be picked just at the time it ripens; for, if it were delayed, the cotton would fall from the pods, and be damaged or wholly destroyed by lying on the ground for a long time—more especially if the soil is damp at the time it falls. But when it happens to lie on the ground only a short time, and gets soiled by it slightly, it is gathered up and sold for *stained cotton*, at a price lower corresponding to the damage done to it. Sea island cotton can be cultivated in Tennessee, one of the United States of North America, also, in the States of North and South Carolina, and, to a certain extent, in Alabama and Mississippi; so it is evident that it is not for want of land, properly suited for its growth,

that a larger quantity is not brought to market, but rather, that the price got for it, by the planters, does not remunerate them for their capital and time.

These remarks, and the following table, which is taken from the *Manchester Guardian*, show a few interesting things connected with cotton growing. The table, which is compiled from reliable sources, exhibits the date of first bloom, the date of killing frost, and the extent of the crop, for each year, since 1836. The returns for the year 1861 to 1864 are imperfect, and therefore omitted.

Year.	Date of First Bloom.	Date of Killing Frost.	Crop in Thousands of Bales
1836.	June 4.	October 11.	1,422,000
1837.	May 7.	October 27.	1,801
1838.	June 14.	October 7.	1,360
1839.	May 21.	November 7.	2,177
1840.	June 6.	October 17.	1,634
1841.	June 10.	October 15.	1,683
1842.	May 17.	November 1.	2,378
1843.	June 12.	October 15.	2,030
1844.	May 31.	October 30.	2,394
1845.	May 30.	November 3.	2,100
1846.	June 10	November 1.	1,778
1847.	May 29.	November 27.	2,347
1848.	May 30.	November 20.	2,728
1849.	June 6.	November 8.	2,096
1850.	June 24.	October 26.	2,355
1851.	June 5.	November 6.	3,015
1852.	June 3.	November 7.	3,202

Year.	Date of First Bloom.	Date of Killing Frost.	Crop in Thousands of Bales
1853.	June 10.	October 25.	2,930
1854.	June 12.	November 5.	2,847
1855.	May 30.	October 25.	3,527
1856.	June 4.	October 16.	2,939
1857.	June 24.	November 20.	3,113
1858.	June 1.	November 7.	3,851
1859.	May 31.	November 7.	4,669
1860.	May 25.	October 30.	3,656
1865.	June 23.	October 20.	2,193
1866.	June 11.	October 25.	2,019
1867.	June 1.	November 6.	2,593
1868.	June 13.	November 24.	2,439
1869.	June 11.	October 28.	3,154
1870.	June 9.	November 18.	4,352
1871.	June 12.	October 10.	2,974

An examination of these dates shows that out of thirty-two years there were but three in which killing frost occurred before October the fifteenth; fourteen in which it occurred between October the fifteenth and October the thirty-first; eleven between October the thirty-first and November the fifteenth; and five in which it came after November the fifteenth. It is obvious also that, whilst a late date of killing frost does not invariably concur with a large crop, it generally does so; this is especially the case when an early bloom and a late frost run together, thus giving a long growing season. In short, it will be found that next to the quantity of land planted and the character of the season, the circumstance most closely

affecting the extent of the crop is the length of the period intervening between the date of first bloom and the date of killing frost.

It will be observed in the foregoing table that the quantity of bales is given in thousands; so, by adding three cyphers to the figures given, the full amount of bales will be seen. The table applies only to the cotton grown in the United States of America.

AMERICAN SHORT STAPLE COTTON.

Besides the cultivation of sea island cotton, the United States grow a large quantity of the short, and medium length staple, kinds. Indeed, the largest quantity of it comes from America, and is known by different names, such as Orleans, Mobile, Georgia, uplands, &c.; but there is not much importance attached to the names, for the quality may change in the course of a few years, although no change of situation has taken place, and the cotton will still retain the old name. For a long time "New Orleans" was a name given to certain kinds of cotton, but the name was derived from the name of the place from which it was shipped, without reference to the place in which it was grown. In all the Southern States of the Union the cotton plant can be cultivated, and is now grown in Alabama, Mississippi, Rhodes, North and South Carolina, West Tennessee, Georgia, and

Virginia, and has become one of the principal productions in a number of these States.

The growing of cotton in America did not commence till near the end of the seventeenth century, and we have no record of any having been sent to Britain before the year 1790; but just about a year or two before the war between the North and South began, the crop of American cotton had reached four millions six hundred and sixty-nine thousand bales, and for forty years back the cultivation of cotton in America has been on the increase; but it got a check in the years that the civil war was going on, and for some years afterwards, no doubt caused by the emancipation of the slaves being so sudden. However, since the year 1866 it has been on the increase again, and by the year 1870 the crop had gone up to four millions three hundred and fifty-two thousand bales, thus showing that the growing of cotton was a business that was paying the planter. The greatest part of the crop is shipped out of the country. Taking the average price at sixpence per lb., which is rather below the real average, and each bale at four hundred pounds weight, then the sum realized would be £43,520,000, which shows the immense importance of the cotton trade to the Americans.

The following table shows the quantity of cotton grown in the United States of America from 1794 to 1834 inclusive, the years 1815, 1816, 1817, and

1818 are omitted. It appears from this table that the crop varies in quantity, but on the whole it keeps increasing, and the slave population keeps increasing also, for in 1790 the slave population was six hundred and ninety-seven thousand, and in the year 1800 it was eight hundred and ninety-six thousand, and in ten years afterwards the number was one million one hundred and ninety-one thousand, and in 1830 the slave population had increased to two millions ten thousand and some odd hundreds, and in 1860 there were upwards of four millions slaves in America.

Year.		Bales.	Year.		Bales.
1794	..	5,340	1813	..	62,030
1795	...	20,901	1814	...	59,094
1796	...	20,355	1819	...	303,589
1797	...	12,628	1820	...	369,800
1798	...	31,200	1821	..	539,038
1799	...	31,774	1822	...	588,139
1800	.	59,299	1823	..	509,600
1801	..	67,700	1824	...	560,000
1802	..	91,670	1825	...	710,000
1803	...	137,018	1826	...	937,000
1804	...	127,060	1827	...	712,000
1805	...	127,966	1828	...	857,000
1806	...	122,225	1829	...	976,845
1807	...	213,148	1830	...	1,038,847
1808	...	35,434	1831	...	987,477
1809	...	169,934	1832	...	1,070,438
1810	...	310,871	1833	...	1,205,394
1811	...	206,860	1834	...	1,254,328
1812	...	96,291			

Of the other countries that grow cotton, and send part of it to Britain, the one that comes next to America in quality is Egypt. Cotton spinning was pretty well advanced in England before any cotton was received from Egypt, none being sent before the year 1822; but, ever since the Egyptians began to export it, the quantity has been increasing, and the quality, from what it was at first, has been greatly improved; what is styled "Long Staple Egyptian" was greatly improved by the introduction of seeds from other countries. The cotton grown from the seeds received from Cyprus, Brazil, and the American sea island, sometimes brings a price nearly as high as the American sea island, and frequently ranks with the lower qualities of it. It has a fine long and strong staple, and makes very excellent warps for any numbers below a hundred hanks to the pound. It was at one time not very well cleaned, but the planters have paid more attention to the cleaning process for some time back, which is the reason that it brings a higher price now than formerly. Some manufacturers have an objection to the high yellow colour that the Egyptian cotton sometimes has, because it is more difficult to bleach than the yarn spun from the pure white cotton; but that is a very small fault, and is only objected to by some spinners.

The common short staple cotton that comes from Egypt is of a most mixed description, which shows

that it is gathered from different kinds of plants, and that the Egyptians have not a uniform mode of cultivating it. A number of the plants from which the cotton is got are what might be called trees, for they grow to the height of eighteen and twenty feet, and continue to grow and bear cotton for a number of years. When the trees attain a certain age, the quality of the cotton deteriorates every year afterwards, until it is not worth the picking, in ordinary seasons. But when cotton is selling at a high price there is an inducement to continue to pick from the old trees; and thus the number of qualities is increased. There are other things that help to keep the price of the lower qualities down, such as the careless way in which the cotton is put up, and also in the ginning. I have seen some bales with the seeds so numerous, mixed up with the cotton, that after it was put through the willow, there would be more than a peck of seeds from one bale, and some with a large quantity of sand and other impurities mixed up with the cotton. But, upon the whole, the Egyptian cotton is very well liked, and some splendid yarn is spun from it, when it is not mixed with the inferior stuff. The lower qualities are, in general, spun up into the coarsest numbers of weft, and some of it is used for candle wicks.

COTTON FROM INDIA AND OTHER PLACES.

The varieties of cotton that are grown in India are numerous, and we receive a great portion of it. One of the kinds is known by the name "Bourbon," the name being taken from an island in the Indian Ocean, situated about four hundred miles east of Madagascar. Although little or no cotton comes from the island at present, the seeds of cotton grown there were introduced into other places, at what date is uncertain, and the name is still given to the cotton grown from these seeds. It is a superior cotton, and was used at one time for spinning fine yarns, but the long staple Egyptian and sea island cotton is now preferred to it.

The cotton that goes by the name "Surat" is a dirty short staple article, and is in general the lowest priced cotton in the market; there is a large quantity of it used for low numbers of wefts. "Bengal" and "Madras" are names given to other kinds of Indian cotton. The best kinds are used for spinning warps of a low count, and a very large quantity of this yarn, along with the wefts spun from "Surats," are woven up into the low priced shirtings. It is generally the low price that makes these cottons sell, for they have to compete with the low qualities of the American cotton. Many of the cotton bearing plants of India last for a number of years before they are renewed, and

that may account for the different qualities in the same species of plants.

Notwithstanding the inferiority of the Indian cotton, and the low price it brings in the British market, in Hindostan the natives can spin a very fine thread out of it, which they weave into muslins that were celebrated for their fineness, until they were surpassed by the British muslins, made from the fine yarns, that were spun by the mule jenny.

Some of the planters in Madras have brought forward a very good quality of cotton, which was reared from a superior seed received from America. It is fine in the fibre, white and glossy, with a silken appearance, and it brings a higher price in the market than the common Bengal and Madras cottons do. As remarked before, the quality of cotton wool is found by inspection, as to the length, strength, and fineness of the filaments, and freedom from impurities and extraneous matter.

The cotton that is received from China is, in the opinion of some, better than the same qualities that are brought from India. It is soft to the feel, very short in the staple, and has a high yellowish colour, which renders it unfit for making into cloth that is to be sold in the unbleached state, although, in China, this high yellow colour is looked upon as an advantage it has got over the white cotton.

In finishing this subject on cotton, we will give, in conclusion, the following, which was written some time ago, on "The Husbandry of Cotton." It will give the reader an idea of the different kinds, and the opinion that was held concerning the qualities, at the time:—

1. "Among the cottons of North America, or the United States, are to be noted that of Georgia short and long stapled, Louisiana, New Orleans, Carolina, and Tennessee. The short stapled Georgia is worked up chiefly into the coarser yarns of No. 30 and under, but when mixed with the Egyptian Mako, it may be spun up to No. 40. The bluish white cotton of Louisiana is of a better quality, but ranks below the long stapled Georgian, the Brazilian, and certain of the West Indian cottons. It is fit for spinning as high as No. 50, but is sometimes deteriorated by a number of little seeds left in it by imperfect ginning. The Carolina is also preferred to the upland Georgia, as well as the cotton of Tennessee and New Orleans, which are often weak fibred; yet some of the latter are fine enough to spin yarns as high as 100.

2. "The West Indian cotton wools of the best sorts resemble in length of staple the Sea Island, the Bourbon, the superior Spanish, and the South American, that of Porto-Rico is held to be the best; after which come the others in the following order, namely: Curaçao, St. Domingo, Martinique, Gaudaloupe, Barbadoes,

Jamaica, St. Christopher, St. Lucie, St. Thomas, Grenada, St. Vincent, Dominica, Tortola, Montserrat, Bahama, Cuba, St. Jago, Antigua. The last may rank with the best of the Levant cottons. Of the West Indian cottons, it should be remarked that their cultivation has been much neglected of late years, since sugar came so much into play; and that their qualities do not correspond with the above, which is their ancient and natural order. The Gaudaloupe has often a reddish tinge, has a long staple, and is easy to spin. It, and the best of the St. Domingo wool, will furnish yarn as high as 100 in number.

3. "South America is capable of affording excellent cotton wool, of which the best example is the Brazilian, called Maragan, Bahia, and Pernambuco, which have sometimes been made into yarn as fine as No. 200 and upwards. They deserve to be placed immediately after the Sea Island Georgian, and the Bourbon, although the Maragan is often ill cleaned. The Minas-Geraes, the Para, and Ceara, are of inferior quality, and are rarely spun into finer yarn than No. 60. The Rio Janeiro is a slight, dirty, and dingy kind of cotton wool, upon a par with the worst sorts of the West Indian. Among the remaining varieties of the South American, the Cayenne is most esteemed, on account of the length, whiteness, and lustre of its filaments, and it may be classed with good Brazilian.

After it comes the Surinam, with long yellowish staple, which has been occasionally spun into No. 200; those of Demerara, Essequibo, and Berbice are generally inferior, as well as of Lima, the Curaçaos, and Cumana. The Carthagena is coarser and dirtier than the preceding, but has greater length and strength of staple.

4. "The East India cotton wool is, generally speaking, inferior to the American, and even to the better sorts of the Levant cottons. The Surat, which is the most abundant, is ill cleaned, yellowish, tolerably fine, but very short in the staple. The Madras, Siam, and Bengal, are of very variable quality; the last is white, silky, and has sometimes been spun into No. 50. The Nanking cotton was at one time celebrated, but it is now little known in Europe.

5. "Under the Levant cotton wools are comprehended all those grown in European and Asiatic Turkey, such as that of Macedonia, of Smyrna, and the Levant properly so called, all of which are distinguished by considerable whiteness, but have a moderate length of staple, so that they can rarely afford yarn finer than No 60. The best kinds of the Macedonian cotton are the Uschur, or the Zehent wool, and the Salonichi; Cira wool is a very poor article, not workable into finer yarn than No. 20. A great variety of cottons come into the market under the name of Smyrna, because this is the general shipping

port for most of the cottons of Turkey in Asia. They are perhaps inferior to the best Macedonian and East Indian, and furnish chiefly coarse weft yarns and candle wicks. The best varieties are the Arar, Kassabar, and Kirkadadoch. The most highly esteemed sorts are the Subuschat and Kinik; those of Cyprus and Acre are inferior, the worst are those of Bender and Altah.

6. "Africa furnishes, from the isle of Bourbon, the best species of cotton wool, almost as much prized as the Sea Island, but it suffers a greater waste in the manufacture. It is uniform, clean, fine, and silky, rivalling the Levant in whiteness; it may be spun into the finest yarn. The Egyptian, or the Alexandrian cotton wool, known in commerce under the name of Mako, or Maho, has a fine readily twisting filament, admits of being mixed with other kinds of cotton wool, but is often foul, and interspersed with unripe fibres. It has of late years quite supplanted the Macedonian in the cotton manufactures of Austria. The Senegal cotton ranks with the middling cottons of the West Indies, and with the good Levants.

7. "The principal cottons known in the trade under the title of Italian, are grown in Malta, Sicily, and Naples, the Sicilian being the best. The next are the cottons of Castellamare and Della-Torre, in the neighbourhood of Naples, which approach in quality to the cotton of Louisiana. The Malta cotton ranks with

the inferior West Indian. The Biancavilla, a variety of Neapolitan cotton, suits well for mixing with the Mako, and then affords (in the proportion of three to two of Mako) a good yarn of from 30 to 50 in fineness of number. Mixed with upland Georgia it is spun into Nos. 30 and 40.

8. "The best kind of Spanish cotton wool is the Motril, from the kingdom of Grenada, which deserves to be placed immediately next to the first Brazilian. From the fineness of its staple it may be spun into yarns of a high number."

CHAPTER II.

PROGRESS OF SPINNING.

The rise and progress of spinning, has formed a theme for different writers in former times, when the factory system was young and small, compared to what it is now, and some things they have related are very interesting to those who study the subject, and I will very briefly, state some of the events concerning it, and then take notice of thread making.

When and where cotton yarn was first spun is a question that cannot be answered correctly, but that it was spun as far back as twenty-three hundred years ago, there is no doubt; and it is more than probable that it was first spun, and woven into cloth, by the Indians. It is well known from the records of ancient history, that the spinning of flax was practised in Egypt even further back, but if they spun cotton also, there is no notice taken of it, at the time, by those historians who write about the linen yarn, and the cloth that was woven with it, although some of them are very particular in the description of the fabrics that were made with linen yarn.

In ancient times the spinning was done by the distaff and spindle—a very simple apparatus. It consisted of a small rod of polished iron, with a ball of iron or clay at one end, which acted as a fly-wheel, and kept it turning round, after it had got an impulse from the left hand of the spinner, to set it in motion. The thumb and finger of the right hand drew out the fibres of the cotton to the required fineness, and this the Hindoo weavers could do to a surprising degree of fineness, but the quantity they could do, was extremely small. After the distaff and spindle had been in use —for how long I cannot say—the common spinning wheel was introduced, which was a great advance in spinning, as regards quantity, but none as to the quality of the yarn. Spinning wheels are generally made, so that they can be driven by the foot acting upon a treadle, or lever, which gives motion to the wheel through a crank and connecting rod. After the cotton is carded, and placed upon a rod of wood (called a rock, or staff), the spinner sits before the wheel, and, having the use of both hands, employs them in drawing out the cotton fibres to the size of yarn wanted, while at the same time the wheel is kept running by the action of the foot, giving the twist to the yarn.

This wheel was in use in Britain in the fourteenth century, and was the only machine used for spinning, up to the time when some attempts were made to

drive more spindles than one by the same wheel, about the year 1741. At this time, the manufacturers of cloth in Lancashire had large orders for several kinds of cloth, the warp of which was linen, and the weft cotton yarns. The manufacturers supplied the weavers with the warps, and the weavers had to provide the cotton wefts themselves. The female portion of the weaver's family was principally employed, previous to this time, in spinning linen, or sheep's wool, very little cotton yarn being spun; but now, when a demand for cotton wefts had arisen for the mixed fabrics, the making of it was better paid, and the spinners were very much sought after. When the weaver could not get a sufficient quantity of weft spun in his own family, or neighbourhood, he had to travel round the country, courting and coaxing the spinsters, besides paying them, to get his wants supplied; and even with all this, weavers were frequently unable to fulfil their contracts with the manufacturers in the stipulated time, and this caused the weavers to pay the penalty they came under to the manufacturer. The trade went on in this uncertain way for many years, and the demand for goods with cotton weft kept still increasing, which caused both the masters and the workpeople to turn their attention to the subject, to study how they could best increase the quantity of cotton weft; for it was evident, that unless some increase were made, the manufacturers would have to

refuse the orders that were offered them. This was well known all over Lancashire, and the matter was taken into consideration even by those not immediately interested in the business, and the consequence was, that a number of experiments were made with a view of multiplying the spinning of cotton weft. I will, however, take notice of only one of these experiments.

Previous to 1736 the carding of cotton wool was done with two hand-cards, either by the spinner or an assistant, and the rovings were placed on the rock of the spinning wheel. About this time an improvement was made on carding, by using what are called stock cards, then a still further improvement was made by the invention of the cylinder card. When carding by the cylinder was introduced, it became a business by itself, the spinner receiving the cotton in rovings from the carders. This, we may say, was the first step in advance for many years, and by this improvement it was easier to increase the spinning of yarn.

About the year 1765, James Hargreaves invented a machine which contained eight or ten spindles, and it spun the yarn on the same principle as the one-thread wheel, namely: drawing out the card roving a given length, and twisting it into thread, then winding it on to the spindle to form the cop. This machine was called the Spinning Jenny. It had no drawing rollers for reducing the rowing (or roving) to

the size wanted, and that part of the machine which contained the spindles was stationary, and the part that contained the roving moved from the spindles, something after the fashion of the spinster's hand, and for the same purpose. From the construction of this machine, it is evident that it never could make as good yarn as the mule or throstle. It gave, however, a great impulse to the spinning of yarn by machinery, and before 1768 a number of these machines were at work. Hargreaves was a weaver when he invented the Jenny, and he contented himself, for some time at first, with spinning the weft required for his own web, it being, at that time, the custom for the manufacturer to supply the warp, and the weaver to provide the weft for it. It does not appear that he made his plan of spinning public at first, for it is said, that after it began to be known in the district, the spinsters and their partisans broke into his house in a riotous manner, and destroyed the hated rival of their fingers. Finding the fruit of his ingenuity, toils, and privations blasted, and his further prosecution of the plan impossible, amidst an enraged populace, who even threatened his life, he migrated to Nottingham in 1768, where he found in Mr. Thomas James, a joiner, a partner willing and able to assist him in erecting a small spinning mill upon the Jenny plan. For this invention he obtained a patent in the year 1770, under the following title:—

"For a method of making a wheel or engine of an entire new construction, and never before made use of, in order for spinning, drawing, and twisting of cotton, and to be managed by one person only; and that the wheel or engine will spin, draw, and twist sixteen or more threads at one time, by a turn or motion of one hand, and a draw of the other. One person with his or her right hand turns the wheel, and with the left hand takes hold of the clasp, and therewith draws out the cotton from the slubbing box, and being twisted by the turn of the wheel in the drawing out. Then a piece of wood is lifted up by the toe, which lets down a presser wire, so as to press the threads so drawn out and twisted in order to wind or put the same regularly upon bobbins, which are placed upon the spindles."

Mr. Hargreaves had made and sold a number of the Jennies before the time he took out his patent, so that when they were beginning to be appreciated, and were promising him a recompense for his time and trouble, he found that his invention could not be sustained in a court of law. He must have thought that his claim was a good one, for he refused to accept three thousand pounds that were offered him by the parties that were using his machines, for permission to continue to work them, but wanted a larger sum which they would not give. Hargreaves died in 1778, and it is stated by some, that at the time of his death he was in poverty,

and by others, that, though not by any means wealthy, he was tolerably well-off, and that he left a sufficiency for the support of his widow and family. Be that as it may, it is well attested that the Spinning Jenny, with only a few trifling improvements, was largely used in Lancashire for the spinning of wefts; in the houses of the weavers and manufacturers it was still quite of a domestic character, and one person could spin as much as twenty or thirty could do with the one spindle wheel, the quantity being regulated by the number of spindles in the machine. When the machine exceeded fifty or sixty spindles it was rather much for a female to drive. When they were made larger some other power for driving them had to be resorted to.

It was great advantage to those who used Hargreave's machine that the cylinder card was introduced before it, as it enabled the spinner to get the rovings more readily than he could either with the hand or stock cards; on this account the Jenny was more generally used than otherwise it might have been. As the wages that could be made in working this machine were much higher than those earned at other trades, many left the work to which they were accustomed, and learned spinning. Yet, notwithstanding the good pay that was being made at the spinning machines, a number of people, in several counties in England, rose in a riotous manner and destroyed all the machines that had more than twenty

spindles. If the people that destroyed these machines had just thought for a minute of what they were about to do, they surely never would have acted so foolishly. It was the Spinning Jenny that had raised the wages of a great number of them, and enabled them to do more work with less labour. But it seemed as if they wished to give three or four days' labour for one shirt, when it was in their option to get it for one day's work; or, to put it another way, they did not wish to have anything they required for the least amount of labour, but would rather have a lot of work to give for it.

The foolishness of these rioters is too obvious to need comment. It reminds one of the following illustration, intended to show the absurdity of suppressing the use of machinery, in order to give more manual labour:—"When one has gone to the well for water, let him carry it ten times the distance required, before using it, and thus he will increase his work tenfold." It seemed to be upon this principle, that, instead of having the weft spun in one day, they wished to have ten days to spin it. This destruction of the machines, made people, with a little capital, unwilling for a time to invest their money in that branch of business, and made some others leave it, and the place in which the riot was, in disgust.

At the very time when the Spinning Jenny was being introduced and worked, several individuals were

planning and experimenting with machines for spinning cotton. We find that in the year 1769, Richard Arkwright obtained his first patent for his Throstle Spinning Frame, which was the first machine that could draw and spin an evenly thread, and was the forerunner of the vast amount of trade that has been going on since that period, not only in the cotton trade, but in almost every other business—for the prosperity of the one gives an impetus to the other. Indeed, the cotton trade is so intimately connected with the work of the engineer, the machine-maker, the miner, and a whole host of others of smaller importance, that when there is a stagnation in the cotton spinning all the others are affected.

After Arkwright had got his machine into working order, and had overcome difficulties in connection with money matters, by getting some person with sufficient capital to enable him to start it, he built a small place at Nottingham, and fitted up some of the new machines, and a gin to drive the machines, similiar to that used by farmers, which was worked by horses—the horse being the motive power. After this trial of his new business, he erected a larger mill at Cromford, in Derbyshire, in the year 1771. At this place the motive power for driving the machines was a water-wheel, and the yarn spun by them was called "water twist," which name continues to this day for the yarn that is spun by the throstle frame.

The original throstle (or water frame) was in principle much the same as it is at the present time. When Arkwright at first fitted up his spinning machines, the framing was made of wood—iron working not being so far advanced as it is now—and each length of rollers had a system of driving gear for itself, and the one length could be working when the other was stopped. Some time afterwards, improvements were made in this respect, but before proceeding further in noticing these, we will give a few notes from Arkwright's specification for his first patent of 1769. In the preamble it is stated:—"By hard study and long application he has invented a new piece of machinery, never before found out, practised, or used, for the making of weft or yarn from cotton, flax, and wool, which would be of great utility to a great many manufacturers, as well as to His Majesty's subjects in general, by employing a great number of poor people in working the said machinery, and by making the said weft or yarn much superior in quality to any heretofore manufactured or made." This last part about the superiority of the yarn, is beyond all dispute, for the roller plan for reducing the fibres of the cotton to the proper size, is the essential part of his invention, and is the greatest improvement that has been made in spinning. He describes his machine as being driven by a cog wheel, and wooden shaft, which receive their motions from a horse

Before the year 1776, Arkwright had greatly improved the whole system of cotton spinning, by introducing machines for the preparation of the cotton before it is made into yarn. Among these are the Drawing Frame and Stretching Frame, which, with the others, will be taken notice of in their order. He also improved the carding machine, although it was not he who invented it.

For what he did, in the way of inventing and improving these machines, he took out a patent in December, 1775, but it was disputed, and set aside by the court, some years afterwards.

The alterations that were made on the throstle (or water frame) a few years after it was invented, were the doing away with the system of having a distinct driving apparatus for each length of rollers, and the introducing of one cylinder, of a length sufficient to drive all the spindles in the frame, the coupling of each length of rollers to the one next it, and the having only one set of wheels and pinions on each side of the machine for driving the rollers.

These changes simplified the driving gear very much; also reduced the first cost of the machine, and the power required to drive it. The throstle frames, at which I first learned to work, had been made shortly after the time that these alterations took place. The two ends of the frame were made of wood, also the rails for joining the two ends together. They were

made very strong to prevent vibration, consequently looked clumsy, and took up more room than those made of cast-iron. On each end of the frame a cast-iron plumber block, with brass bushes, was bolted down to the wood for the journals of the tin cylinder to run in, and small brass steps, or bushes, were driven into the wooden rails for the lower ends of the spindles to run in. For the upper journal of the spindle there was another wooden rail, and in it was fitted a half brass bush for each spindle; and the strain of the list, or lace, which drove the spindles, kept them close up to the brass; and, to prevent the spindles from coming forward, a piece of wood for every pair of spindles, was fixed on the front by two round brass nuts, which could be turned by the finger and thumb, so as to adjust the journal to the proper degree of tightness. This was a constant annoyance to the spinner, for it would be sometimes too loose, and at other times too tight. The coping rail was also made of wood, and similar in shape to the present iron ones. All the under rollers were fluted, but the top rollers were covered with leather. The driving end of the frames was much higher than the present machine, for the purpose of giving room for the fly-wheel. This fly-wheel was about forty-two inches in diameter, and was fixed on the same shaft as the pulleys, and they were eighteen inches in diameter—this end of the machine being made double

for the purpose of supporting the driving gear. On the end of the tin cylinder was a small pulley, and a belt was put on the fly-wheel for driving the small pulley and cylinder, which drove the spindles only, the rollers being driven by a pinion on the end of the fly-wheel shaft, and the wheels were so arranged that the one pinion was made to drive the rollers of both sides of the frame. The bringing up of the speed of the spindles in this manner, caused a heavy strain to be put on the belt that gave motion to the whole machine, and it was a frequent occurrence for the belt to slip off in starting the frame, if it was not assisted by the hand of the person who was putting it in motion; and this was done by turning the fly-wheel, at the same time as the worker was shifting the belt from the loose pulley to the tight one. More than once I have seen the worker get a broken arm when in the act of starting a frame, by the arm being caught between one of the spokes of the fly-wheel and the end of the frame. But that danger is all done away with now, as the driving belt is at once taken to the pulleys on the end of the cylinder, the speed being brought up by the shafting between the engine and the spinning machine. At that time there were no shifting stands, for the purpose of setting the rollers to answer the different lengths of the cotton staple, but about two or three years after I had been at the work, all the old rollers were replaced by new

ones. This was done to enable the proprietor to spin a cotton with a shorter staple. The under rollers were made much the same as the old ones, and could not be shifted, but the top ones could be shifted, by an arrangement in the saddle bars; the front under roller and the middle one were placed as close to one another as they could work, and the back one was fully one inch from the middle one. The front top roller was covered with leather, and was pressed down upon the under front roller with a weight; but the middle and back rollers had no pressure put upon them, it was only the weight of the rollers that held the roving. The middle top roller was half-an-inch in diameter, and was smooth, not fluted, and the back top roller was an inch and one eighth in diameter, and was fluted. It was the weight of this roller that kept the roving from being pulled through by the front one. The middle one, from its lightness, only pressed slightly on the roving, but still it was between the front roller, and the middle one, that the draught in the roving took place. All the pinions and small wheels about these machines were made of brass. The rovings for these throstles were finished with the stretching machine (or billy), and were built on the spindles in the shape of a large pirn cop, and when brought to the spinning frame, a light tin skewer, about the same thickness as the spindle of the stretching frame, was inserted in the rove, and the

rovings were then placed in the throstle to be spun into yarn. It was after the year 1850, before those machines were put out to make room for the more improved ones.

When Arkwright's spinning machine was making first-rate yarn for warps, and Hargreaves' Jenny producing wefts of an inferior quality, another invention was being experimented upon, with a view to spin better yarn for wefts. The person, who was trying the experiment, was Mr. Samuel Crompton. He was born at Firwood, in Lancashire, in the year 1753. His father, being a farmer on a small scale, near Bolton, young Crompton was sent to learn the spinning on one of Hargreaves' machines. When he had been about four years working with the Jenny, he began to consider how the quality of the yarn could be improved; there is no doubt he would hear about Arkwright's roller spinning machine, but whether he had seen any of them does not plainly appear. However, after spending five year's labour on his invention, he brought forward a machine which embraced the principal part of Arkwright's invention, and also the best part of Hargreaves' plan, and the two combined, produced a most excellent machine for spinning fine numbers. This machine, when introduced, was named the Mule Jenny. The roller system in this machine was the same as Arkwright's invention, but the spindle carriage was not the same as Hargreaves', for in

Hargreaves' machine, the spindle frame did not move to and from the rovings, and in Crompton's, it was the carriage with the spindles, that receded from the rollers.

The introduction of the Mule, was the starting point of a new class of goods being woven in this country, for, before this time, all the fine muslins were woven in India; indeed, all the fine cotton goods that required fine warps and wefts, were after this time, introduced into the weaving trade; for, although Arkwright's machine was admirably adapted for spinning any numbers below 40^s, either for warp or weft, the very nature of it prevented it from making the finer kinds of yarns. It was a number of years after the invention of the Mule before it came to be much used. But when Arkwright lost his claim for his second patent in the year 1785, the new machine was very much run upon, and it spread all over both England and Scotland. Mr. Crompton's plan for combining Arkwright's and Hargreaves' machines as another new machine, was a good subject for a patent, and his claim could not be set aside, either by the one or the other. Yet he did not protect his invention patent. For what reason he did not apply for a patent is not explained, but we find a statement of what might have been a reason, for not trying to secure protection, and it is this:—"He often said that what annoyed him most was that he was not

allowed to employ his little invention by himself in his garret; for, as he got a better price for his yarns than his neighbours did, he was naturally supposed to have invented some superior mechanism, and hence became an object of the prying curiosity of the people for miles around, many of whom climbed up at the window to see him at his work. He erected a screen in order to obstruct their view, but he continued to be so incommoded by crowds of visitors, that he resolved at last to get rid of the vexatious mystery, by discovering the whole contrivance before a number of gentlemen and others, who chose to subscribe a guinea a-piece for the inspection." In this way he collected about £50, and was hence enabled to construct another similar machine, upon a better and larger plan. According to the old patent law, the exposing of an invention made the patent invalid. That Mr. Crompton had his difficulties, appears from the following extract from one of his letters. In writing to a friend he says:—

"In regard to the Mule, the date of its being first completed, was in the year 1779. At the end of the following year I was under the necessity of making it public, or destroying it, as it was not in my power to keep it, and work it, and to destroy it was too painful a task, having been four and a-half years at least, wherein every moment of time, and power of mind, as well as expense, which my other employment would

permit, were devoted to this one end, the having of good yarn to weave; so that, destroy it, I could not."

Mr. Crompton was not allowed to go unrewarded for the invention of the Spinning Mule, because, a number of gentlemen in and around Manchester, the centre of the cotton spinning business, subscribed so much each, and what they obtained amounted to five hundred pounds, which enabled him to increase his manufactory in Bolton. Besides this sum, Parliament granted him, in the year 1812, the sum of five thousand pounds, as a reward for his invention. At the time that this sum was voted by Parliament, Mr. Crompton would be a man of nearly sixty years of age, and his Mule had been in operation for upwards of twenty-six years, and it was estimated that there were four millions of spindles at that time in operation on his plan. This sum of five thousand pounds he advanced to his sons, to enable them to carry on business as bleachers, for the support of the family. But the money was soon lost, and they were reduced to poverty, along with their sister and father. Then another subscription was raised, and applied in buying a life annuity of sixty-three pounds for Mr. Crompton, who, however, did not live long after this was settled upon him, for he died on the twenty-sixth day of January, in the year 1827.

Like Hargreaves' Spinning Jenny, the Mule, when first brought out, was worked by the spinner's hand,

but it was not long until water or steam power was applied to drive it.

In the year 1780 a cotton spinning mill was erected in Manchester, and filled with new cotton spinning machines. The motive power for driving the machinery in this mill, appears to us at this time rather singular. Newcomen's steam engine had been advantageously employed, for many years before this time, for pumping water from coal mines, and Watt's engine had not come into popularity, so the proprietors got one of Newcomen's engines fitted up, for the purpose of lifting water to a higher level and then allowing the water to drive a water-wheel, the wheel giving a continuous motion, the engine stopping for a time at every descent of the piston. By this arrangement a regular motion was derived from an irregular one.

When Watt's steam engine was employed for driving machinery, it gave a great advantage to the cotton spinners, and it was introduced just in time to encourage the growth of the business, for without it, the trade would have been confined to localities where water-falls could be used for driving the mills.

Boulton and Watt fitted up one of their engines in the year 1785, at Papplewick, in Nottinghamshire, to drive a cotton spinning mill. This was the first of ɘir engines that was employed for cotton spinning, it was not the first steam-engine that was fitted up for that purpose, for, before this time, Arkwright

had put up one of Newcomen's engines, and applied a fly-wheel to it of sufficient weight to give a regular motion to the fly-wheel shaft. Instead of the pump rod being at the end of the working beam, a strong rod connected with a crank was applied. This crank was fixed on the end of the fly-wheel shaft. When the piston descended by the pressure of the atmosphere, it pulled up the crank, by the opposite end of the beam being raised, this gave motion to the fly-wheel; but, as there was little or no power when the piston was ascending, the fly-wheel had to keep the shaft running for half the time. By this arrangement a great quantity of power was expended on driving the heavy fly-wheel, which made it an expensive way way of driving, and it was soon given up.

Boulton and Watt had, before the year 1791, erected a number of their engines for the purpose of driving cotton spinning machinery. One was put up at Warrington, one in Manchester, and three or four in Nottingham. But we find many of the cotton spinners at this period building their factories on the banks of rivers, not only in England but in Scotland also.

It is recorded, that the first cotton yarn spun in Scotland, by water power, was at Rothesay, in the island of Bute, in an old building that had been used for some other purpose requiring power. After the trial of the cotton spinning, the place was converted

into a mill for grinding corn. A mill of considerable size was afterwards erected at Rothesay, for cotton spinning, which was carried on, for a long time, by different proprietors, until within a few years. The machinery was broken up, but the building still stands at the present time (1877).

At Barrhead, in the parish of Neilston, a cotton spinning mill was built about this time on the banks of a stream, and another at Johnstone about the year 1782. For the next eight or ten years, mills for cotton spinning were being put up in almost every place in which the water power could be obtained. One of considerable size was erected near Lanark, on the north bank of the river Clyde, down in the valley, half-a-mile below the Cora-Linn Falls. A little higher up from the river than the works, a village has been built for the work people, and this, along with the work, is called New Lanark. For a long time, the yarn spun by the throstle frames at Lanark Mills, was well known all over the country as being the best water twist yarn in the market. They are still in full operation as spinning mills. The old machinery has been put out long ago, and new put in. This is the only place in Scotland, which, erected at so early a period, still continues to be a spinning mill—at least, so far as I am aware. The Blantyre Works were erected at an early period by Mr. Monteith, but the spinning is given up. The Duntocher Works are

also stopped, so is the one at Barrhead, also the one that Mr. Kelly was in at Busby—it afterwards belonged to Mr. Crum. This Mr. Kelly, of Busby Mills, was the first to apply the water power for driving the Mule. When Mr. Crompton brought out his machine, it was at first wrought by the spinner's hand, but as the machine increased in size, it became too heavy for the spinner to work, hence the necessity of applying water power. Although Mr. Kelly obtained a patent at the time for his invention, he afterwards gave up his right, and any person was at liberty to use it without payment; and this led many of the spinners to double the size of their Mules. Shortly after this, what is called the Double Mule was introduced, by placing the driving gear in the centre of the machine.

The improvements that have been made upon spinning machinery have been so great, as regards production, that the old kind of machines has been put aside long ago by most, if not by all spinners; and it is not at all requisite now to have the mills put up near running streams, the steam engine being mostly employed for the motive power. Further on there will be occasion to make some remarks on this subject.

It is recorded that cotton spinning was, at an early date, introduced into Ireland, some time between the years 1775 and 1780. The parties that introduced

it, at first thought it would be a good, and also a profitable employment, for the children in the poorhouse at Belfast. Some of them were put to spin on the common wheel, but they could not compete with the new machinery that had been started in England, and Mr. Grimshaw, a gentleman who had been a cotton and linen printer in England, got one of the new machines made in Belfast, and an experienced spinner was brought over from Scotland, to teach the children in the poorhouse to work with the new machine.

After this, a firm was formed by Messrs. Joys, M'Cabe, & M'Cracken, for the purpose of carrying on business as cotton spinners, and they contracted with the Managers of the poorhouse for the employment of a number of its inmates. They sent a man over to England to learn how to work the new machinery, that he might teach others, on his return to Belfast. This start was followed up on a larger scale by Messrs. N. Wilson & Grimshaw, and the first mills, for spinning water twist, was built by them in the year 1784. Between this year and 1800 a number of other spinning mills were erected in Ireland, but the trade in cotton spinning did not increase at the same rate as in England and Scotland, the flax spinning being more in favour with the Irish people; so that a number of places that were put up for the cotton were converted into linen spinning mills, which con-

tinue to prosper to the present time. The flax trade received a great impetus at the time the Southern and Northern States of America went to war with each other. The Southern States of the Union being the place in which the cotton was cultivated, a blockade was put on, so that even the cotton that was grown could not be shipped; and the cotton in this country rose to fabulous prices, and many manufacturers in the cotton trade were ruined, while those in the linen trade, in and around Belfast, made fortunes, which caused a number of new mills to be built in Ireland, for the spinning and weaving of flax.

From the year 1790 onwards, many minds were occupied with improvements in machinery connected with spinning, and it would be difficult to recognize many of the old machines (more especially the preparation ones) in the new ones now in use, so great have been the alterations in them.

Besides those we have named as improvers and inventors in the spinning trade, there are others that deserve to be mentioned, and some of these the writer knew personally. Mr. Neil Snodgrass, a very ingenious and clever mechanic, was the first to apply steam for the heating of spinning factories, which previously were kept at the proper temperature by hot air. The air being heated by passing over stoves, was allowed to go through the different departments of the mill. When steam was introduced, it was

found to be more equally diffused through the rooms, besides being more economical; and this system of heating became universal in factories. Mr. Snodgrass was also the inventor of the Scutching Machine, about the year 1797, and it was brought into use by Mr. Houston, in his mill, at the village of Johnston. After Mr. Snodgrass had a mill of his own, he tried many experiments in connection with spinning machinery.

Other two gentlemen, who were early connected with the cotton spinning trade, were Mr. Owen and Mr. Humphrie. They had been together in England. Mr. Owen afterwards came to the Lanark Mills, and was a partner in the company that carried on these works, and different improvements were made at the time he was there. Mr. Houldsworth was another gentleman who made a number of improvements in connection with cotton spinning; also Mr. Smith, of the Deanston Cotton Works; also Mr. Roberts, of Sharp & Roberts, machine makers, in Manchester; and Mr. Robertson, of Crofthead. These three last-named gentlemen were all, more or less, connected with the Self-acting Spinning Mule, which I will more particularly notice when giving a description of the machines employed in cotton spinning.

The following is a list of the names of those who took out patents, from the year 1800 up to the year 1836, both years included. However, some of the

things the patents were obtained for, were never of any practical use to the trade:—

Name.	Date.	Title.
J. J. Ward.	Dec. 30, 1800.	Doubling.
J. Wood.	June 14, 1803.	Spinning and Reeling.
Thomas Johnson.	Feb. 28, 1803.	Preparing and Dressing.
J. Wood.	Jan. 10, 1804.	Spinning.
John Heppenstall.	June 2, 1804.	Spinning and Twisting.
Thomas Johnson.	June 2, 1804.	Dressing.
Joseph Huddart.	Sept. 21, 1804.	Spinning, &c.
Thomas Margrave.	Dec. 19, 1804.	Throwing and Spinning.
Earl of Dundonald.	Nov. 19, 1805.	Spinning.
Clark & Bugby.	June 19, 1806.	Spinning.
Matthew Robertson.	Oct. 30, 1806.	Combining Machinery.
Thomson.	Feb. 20, 1807.	Spinning.
Samuel Williams.	April 8, 1807.	Spinning.
Laybourn & Milbourn.	Dec. 9, 1807.	Roving.
John L. Bradbury.	Dec. 24, 1807.	Spinning.
John Dumbell.	Aug. 25, 1808.	Flax Spinning.
Harkey.	Nov. 8, 1808.	Roving, &c.
Archibald Thomson.	Feb. 7, 1809.	Spinning.
John Stead.	Feb. 9, 1809.	Making Cards.
Rutt & Webb.	Nov. 21, 1809.	Making Cards.
Richard Varley.	July 7, 1810.	Roving, &c.
Thomas Cranfield.	May 7, 1811.	Spinning and Roving.
J. C. Dyer.	Oct. 30, 1811.	Cards.
Joseph C. Dyer.	Nov. 1, 1813.	Spinning Hemp.
Joseph Rayner.	Jan. 1, 1813.	Roving and Spinning.

Name.	Date.	Title.
George Courtauld	Aug. 4, 1814.	Spindles.
J. C. Dyer.	Dec. 15, 1814.	Cards.
John Wood.	Feb. 4, 1815.	Preparing and Spinning.
William Palmer.	April 4, 1815.	Twisting.
Wood & Wordsworth.	Mar. 2, 1816	Spinning.
Bradbury.	Mar. 9, 1816.	Spinning.
John Welch.	Aug. 3, 1816.	Making Rollers.
William H. Simpson.	July 10, 1817	Spinning.
Samuel Hall.	Nov. 3, 1817.	Singeing.
George Whitham.	April 8, 1818.	Spindles.
Thomas Homfray.	May 28, 1818.	Bobbins.
William Eaton.	June 18, 1818.	Roving and Spinning.
Joseph Main.	Jan. 15, 1820.	Preparing
James White.	July 11, 1820.	Preparing and Spinning.
P. Chell.	Feb. 18, 1823.	Drawing and Roving.
William Crighton.	Mar. 18, 1823.	Carding.
Joseph Taylor.	April 29, 1823.	Spinning, Doubling, &c.
John Green.	June 26, 1823.	Roving and Spinning.
Thomas Leach.	Aug. 18, 1823.	Spinning.
Donkin.	Sept. 11, 1823.	Singeing.
T. F. Gimson.	Nov. 6, 1823.	Twisting
Archibald Buchanan.	Dec. 4, 1823.	Carding.
Jarvis Boot.	Dec. 13, 1823.	Singeing.
John Heathcoat.	Mar. 20, 1824.	Spinning.
J. L. Bradbury.	July 3, 1824.	Twisting and Spinning.
Jeffries & Drakeford.	July 29, 1824.	Swift.
John Price.	Aug. 5, 1824.	Spinning.
J. George Bodmer.	Oct. 14, 1824.	Drawing and Spinning.

Name.	Date.	Title.
William Hirst.	Jan. 11, 1825.	Slubbing, &c.
Andrew Tarlton.	Jan. 11, 1825.	Thorstle.
Booth & Bailey.	Jan. 13, 1825.	Spinning.
Richard Badnall.	Feb. 10, 1825.	Winding.
Richard Roberts.	Mar. 29, 1825.	Spinning.
Maurice.	Mar. 29, 1825.	Preparing.
John F. Smith.	June 21, 1825.	Roving and Spinning.
W. & H. Hirst.	July 16, 1825.	Scribbling and Carding.
Hurst & Carter.	July 16, 1825.	Mules and Billies.
J. C. Dyer.	July 16, 1825.	Winding.
Brooke & Hardgrave.	July 26, 1825.	Carding.
James Kay.	July 26, 1825.	Spinning.
Lamb & Suttill.	Nov. 17, 1825.	Preparing.
Ezekiel Edmonds.	Dec. 3, 1825.	Carding.
J. C. Dyer.	Dec. 9, 1825.	Wire Cards.
Henry Houldsworth.	Jan. 16, 1826.	Roving.
John F. Smith.	Jan. 19, 1826.	Drawing and Spinning.
John Goulding.	May 2, 1826.	Carding and Roving.
Francies Malinen.	May 23, 1826.	Spinning, &c.
Edward Rayliffe.	July 14, 1826.	Drawing, Roving, &c.
De Jongh Maurice.	Dec. 18, 1826.	Roving, Spinning, &c.
Philip Heisch.	Feb. 20, 1827.	Spinning.
James Whitaker.	April 24, 1827.	Carding, &c.
J. C. Daniell.	June 8, 1827.	Wire Cards.
Lambert Dexter.	June 16, 1827.	Spinning.
William Church.	July 13, 1827.	Spinning.
De Jongh.	Dec. 4, 1827.	Spinning, &c.
John Ford.	May 13, 1828.	Carding, Roving, &c.
William Sharp.	Aug. 19, 1828.	Spinning, &c.
Joseph Rhodes.	Sept. 18, 1828.	Spinning and Twisting.

Name.	Date.	Title.
George W. Lee.	May 2, 1829.	Spinning.
Charles Brooks.	June 4, 1829.	Spinning.
John Hutchison.	July 30, 1829.	Spinning.
William Lane.	Aug. 5, 1830.	Roving Frames
Bundy & Molineux.	Sept. 21, 1830.	Roving, Spinning, &c.
Thomas Sands.	Nov. 18, 1830.	Spinning.
William Needham	Dec. 13, 1830.	Spinning, Doubling, &c.
Charles Wood.	Mar. 11, 1831.	Spinning.
John & James Potter.	Mar. 21, 1831.	Spinning and Twisting.
Thomas Knowles.	May 23, 1831.	Mules, self-acting.
Samuel Lambert.	June 2, 1831.	Throstle.
John Milne.	July 13, 1831.	Roving.
James Lang.	Sept. 24, 1831.	Spreading, &c.
Joshua Bates	Oct. 27, 1831.	Roving, &c.
David Selden.	Nov. 22, 1831	Carding and Slubbing.
Henry Gore.	Dec 22, 1831.	Throstle.
John Jellicorse.	Jan. 28, 1832	Spinning.
A. B. Shankland.	April 13, 1832.	Spinning.
Robert Montgomery.	April 26, 1832	Spinning
Hugh Bolton.	June 5, 1832.	Carding.
Joshua Wordsworth.	July 26, 1832.	Drawing, &c.
James Jones.	May 25, 1833.	Roving, Spinning, &c
William Newton.	July 11, 1833.	Roving.
John Howard.	Sept. 21, 1833.	Roving.
John Robertson.	Sept. 21, 1833.	Spinning, &c.
John Travis, Jr.	Nov. 1, 1833.	Spinning.
Peter Ewart.	Nov. 9, 1833.	Mule Spinning.
Dobson.	Feb. 6, 1834.	Roving and Spinning.
James Smith.	Feb. 20, 1834.	Preparing Spinning.

Name.	Date.	Title.
James Smith.	Feb. 27, 1834.	Carding.
James Walton.	Mar. 27, 1834.	Cards.
Richard Simpson.	June 3, 1834.	Roving, &c.
Thomas R. Bridson.	June 10, 1834.	Drying Cotton.
Charles Wilson.	June 17, 1834.	Spinning.
William Higgins.	July 7, 1834.	Roving.
Peter Wright.	July 17, 1834.	Spinning and Twisting
James Slater.	Aug. 23, 1834.	Bleaching.
Sharp & Roberts.	Oct. 8, 1834.	Spinning, &c.
Malcolm M'Gregor.	Oct. 20, 1834.	Slubbing, &c.
James Jones.	Oct. 20, 1834.	Roving, Doubling, &c.
Charles De Bergue.	Nov. 15, 1834.	Spinning and Twisting.
Peter Fairbairn.	Dec. 23, 1834.	Preparing, &c.
Joseph Whitworth.	April 14, 1835.	Spinning, &c.
John G. Bodmer.	May 27, 1835.	Preparing.
James Kean.	July 3, 1835.	Throstle, &c.
Dyer & Smith.	July 17, 1835.	Winding.
Samuel Faulker.	Aug. 6, 1835.	Carding.
Richard Barber.	Oct. 22, 1835.	Reels.
Horsfall & Kenyon.	Dec. 9, 1835.	Carding.
John Houldsworth.	Dec. 9, 1835.	Drawing and Slubbing.
John Hyde.	Dec. 31, 1835.	Carding.
Champion.	Jan. 6, 1836.	Spinning, &c.
Ramsbottom.	Jan. 6, 1836.	Roving, &c.
Ashworth & Greeoaugh.	Feb. 5, 1836.	Preparing.

For many years after 1834, the great majority of the improvements made in connection with cotton spinning machinery, were upon what, in the trade, is called the Self-acting Mule. One little improvement

after another has been made on it, until it is one of the most perfect combinations of self-acting mechanisms that can be seen in any one machine. All that the workers have got to do is to keep in rovings, and *mend the threads* (technically, *piece the ends*), and at regular intervals clean the machinery, and oil all the working bearings. Indeed, it has been brought to such a state of perfection, that it is only the few, who are well conversant with mule spinning, who can see any defects in it, and it is very creditable to those persons that were the inventors and improvers of the machine. The gentlemen who interested themselves with the self-acting mule, in its earlier stages, were the Messrs. Eatons, of Wiln, in Derbyshire, who got a few of their machines tried at Manchester, and some in France. In a mill at Warrington, in England, Mr. De Jongh tried some self-acting mules, and it will be seen from the patent list that he obtained either one or two patents for his improvements, but they did not succeed. But I have no doubt whatever that his failure, along with those of many others, helped to point out to others (who came afterwards to try their plans) what to avoid. Both Mr. Smith, and Mr. Buchanan, who were in the employment of James Findlay & Co., made improvements on the self-acting mules. Mr. Smith, at their works at Deanston, in Scotland, brought out a self-acting mule, which came to be very well liked after

many breakdowns and trials. But it was after the improvements of Mr. Robertson, of Crofthead Mill, in Renfrewshire, were added to Mr. Smith's, that this self-acting mule became popular. Mr. Robertson having obtained a patent for his own inventions, and Mr. Smith for his, they joined them, and then this self-acting mule was known in the trade by the name "The Deanston Self-actor." Mr. Smith of Deanston, was a very ingenious gentleman: he made many improvements on other machines besides the mule machines, both in connection with weaving and spinning, and other trades. Mr. Buchanan of the Catrine Cotton Works, had a self-acting mule also; but very little notice has been taken of it. Mr. Knowles, another gentleman, was one of the early improvers of the mule; also Dr. Brewster. But the self-acting mule that has made the most noise in the trade is the one brought out and completed by Mr. Roberts, of Sharp & Roberts, machine makers and engineers, Manchester. Mr. Roberts, at different dates, had obtained patents for his improvements on the self-acting mule.

THREAD MAKING.

The making of thread is perhaps nearly as old a trade as is spinning, although it was a small business,

compared to either linen or cotton spinning, until lately, and now it has risen to be a very extensive industry, and it is still increasing, more especially the making of cotton thread, at Paisley and other places, caused, no doubt, by the demand for it to supply the numerous sewing-machines that are spreading all over the country.

The parties who first brought thread making into a regular and systematic trade, and who carried it on in all its branches in this country, were Mr. Clark, of Mile-end, and Mr. Alexander, of Duke Street, Glasgow. Both of these gentlemen spun the yarn that was to make the thread, and finished the thread ready for the market. The small bobbins, that the thread is wound upon, they also made at their works, and they had all the appliances for either putting it on bobbins, or making it up into small balls ready for use.

The machines that are used for making thread, are very similar in several respects to some of the machines that are employed in spinning cotton yarns, which will be explained in another place.

CHAPTER III.

PROCESS OF SPINNING.

In this chapter I will merely trace the different processes through which the cotton is put, from the bale until it is made into yarn ready for the market, without stopping to give a full explanation of the different machines, which will be described in another chapter.

It is unnecessary to lay down any particular plan of a cotton spinning mill, as there are so many different ideas concerning the best plan; but I will point out in the course of this treatise, what I consider the best arrangements for the buildings, and also for the different machines, so as to make it complete, and fit to be worked to the best advantage to the proprietor, which is the main thing in any business; for, if the trade in which capital is invested, does not yield a profit it cannot be continued. In a spinning factory, where so much depends upon proper division of labour, and where the least disturbance of any one of the divisions throws all the others into confusion, it is most essential that all the workers in the different

systems should co-operate to work in harmony with one another, so as to prevent any stoppage of the machinery. This is a subject which will be taken notice of in another place.

Before commencing to build a spinning factory, it is requisite for the projector to make considerable inquiry, to obtain knowledge concerning things that are likely to contribute to the success of the undertaking, such as ground rent, situation as regards workers, coals, water, and the markets at which the cotton can be bought and the yarn sold, the form of the mill, the kind of boilers, engines, gearing, machinery, &c.

There is no doubt that a populous district is the best place for workers, and a good situation for a spinning mill, provided there is no other obstacle to make the quantity of workers no object, such as the ground rent, local taxes, water, coals, &c., being so high in price, as to make the work unprofitable; therefore, all the different circumstances must be taken into consideration. The carriage to and from the market, at which the cotton may be bought and the yarn sold, is not so expensive an item as it was at one time, before steam was taken advantage of for that purpose; and it often happens, that the factories erected in country villages, are as profitable as those in large cities.

It is at once apparent, that the factory should be so large that each department will be kept fully

employed; and to keep the machines in the picking house in regular work, the mill will require to have at least eight or ten thousand spindles for medium numbers, and for the finer numbers, at least twenty thousand spindles. But, whatever size the factory is to be, when the situation is fixed upon, plans of the whole should be made out, under the direction of one who is thoroughly acquainted with spinning and all the various machines that are used in the preparation department.

All cotton spinning mills have—or should have—a building outside the *factory proper*, for putting the bales of cotton in when they are brought from the cotton broker's store. This house should be as convenient to the picking room as circumstances will permit; and it should be so situated, that the horse and cart bringing the cotton can get up to the door of it; and the doorway should be as wide as to allow the carter to back the load of cotton into the inside of the store. On one side of the doorway, inside the building, is placed a beam and scales, or some other apparatus, for weighing the bags or bales, when they are being delivered by the carter. Each bag or bale is weighed by itself, the number and weight, when ascertained, are entered in the cotton store book. The workman that weighs the bales, takes them and stores them past, to remain until required at the picking house. The cotton store book (a form of

which will be given afterwards) is one that is very useful when properly kept. In it is entered all the cotton that comes to the factory, and each bale's number and weight, corresponding to the invoice, is put down in one column, the real weight in another, and the difference, if any, in yet another. There is also a column for the tare. As the cotton is required for consumption, it is weighed again, before being taken out of the store. The necessity for these weighings is obvious: cotton being an article that readily absorbs moisture, is rendered heavier by lying in a damp store, and thus, according as the store from which it is brought to the mill is dryer or damper, than that *at* the mill, the weight of the cotton will become less or greater after being there for some time; so it is considered better to have the bales weighed just at the time that they are being taken to the picking house. This weighing also acts as a check on the first weighing, and shows exactly the quantity that goes to the picking house. However dry the store may be, there is always a certain percentage of the weight lost as the cotton passes through the different machines, owing to it becoming less moist, which has been found in practice. Although all the ropes, bagging, sand, seeds, dust, and any other refuse that comes with the cotton, be collected; and tops, flies, stripes, and the yarn spun, all carefully weighed, the aggregate amount given out does not come up to

the weight received in. I have seen a very large deficiency in the course of a year, just from the cotton losing the moisture that was in it before it was made into yarn. The yarn being placed in a damp cellar, will absorb a certain amount of moisture, and consequently increase in weight.

The picking house, as it is sometimes called, is the department to which the cotton is first taken, when it is removed from the cotton store, and it, like the store, should be a building by itself, but not any further from the spinning mill than just to give the space which is required by the rules of insurance companies. In the early period of cotton spinning factories, very little attention was paid to this, and a number of the old mills were built with the picking room inside the walls of the main building. There is no doubt that if the risk of fire were no greater in the picking room than it is in the carding rooms, or the spinning flats, it would be the best place to have it, for the machines could be so arranged as to cause the least possible carriage of the laps to the carding engines. But this arrangement of having the picking room in the main building, causes the insurance rates to be so very much higher, that it more than counter-balances any saving that is made from the extra wages which are paid for carrying the laps from the picking house. In consequence of the high rates of insurance, the modern mills are mostly built with the

picking house detached from the main building, and some of them are made fire-proof, and only the machinery and cotton are covered by insurance. In some cases the proprietor of the mill takes upon himself the risk against fire in the picking house, as the rates for this department are very high. There is no particular plan that can be recommended for the size or the form of the picking house; these will be in accordance with the extent of the mill, and the situation of the ground. When there is no scarcity of ground to build upon, ample space should be allowed for the house, so as to give sufficient room inside for all the machines, and the different divisions for the mixtures; and floor space enough to lay down the requisite number of cotton bales that may be required for the largest mixing. A range of divisions (or bunkers) should be placed along one of the walls of the room in which the machines are, and the space for laying down the bales is between the machines and the boxes (or bunkers) where the mixture is made up. The first machine that the cotton is put through, should be set down right opposite the places where the mixture is made up, reserving the boxes at the other end of the range for tops, flies, and stripes. The scutching machine, being the second that the cotton is put through, it is placed in a position so as to be most convenient for the cotton as it comes from the first machine. The next machine, or

third through which the cotton is put, is called the spreading machine, and it is placed in a convenient position to the scutching machine. An explanation of these machines will be given in another chapter, in which will also be shown the speeds they should be driven at, and how to calculate the speeds. These machines are all put into one flat of the picking house, and below this flat is a cellar, or under flat, for the purpose of receiving the dust that is taken out of the cotton by the machines. It is generally in this under flat that the fan is placed which relieves the picking room of a large portion of the dust that comes from the cotton, and by this means the workers are now very much better off than formerly, when fans had not been introduced for this purpose. The dust is, at certain intervals, removed from the under flat, according to the amount that accumulates in a given time.

Instead of driving the machinery, that is in the picking room, with the engine that propels the gearing and machinery in the main factory, some are of opinion, that it is better to have an engine for driving nothing but the machinery in the picking house.

By having an engine for the driving of the picking house, independent of the main factory, the workers are enabled to go on with the preparation of the cotton although the large engines are stopped, which some-

times happens from some small accident. If the stoppage of the main factory be for a number of hours, of course there will be no use for the picking house machinery being kept going, and, it keeps the picking house quite isolated from the main building; for if it were depending upon the factory engine, some connection would have to be made to connect the power, and fire might pass from the one house to the other, by the openings which are made for that purpose. It is in the picking house that the first operation commences for cotton spinning, which will soon be explained.

I have given, in the first chapter, some remarks about the article cotton, and it is only necessary to make a few, in this place, for the guidance of the person into whose hands the cotton first comes. There are many different kinds of cotton, with a great many names, such as *American*, *Indian*, *Egyptian*, and *Chinese* cotton, and these again are subdivided. Of American cotton we have *Orleans*, *Georgia*, *Sea Island*, and a number of others, which have been named already. Each of these kinds has its peculiar quality, and it is the duty of the person who makes up the mixture, under the direction of the manager, to examine each bale, or sample of bale. It is a common custom, when buying a lot of cotton from the cotton broker or importer, to get a list of the number of bags or bales, with a small sample from

each bag or bale. Every lot has a distinctive mark, and each bag or bale has its own number, and that number and mark are put on the sample. The samples should be taken from the bales at random; and when the bales are brought from the cotton store to the picking room, and laid on the floor side by side, they are opened up by removing the ropes and sheeting. It is at this stage, that the person who has charge of the mixtures, takes the samples, and compares each sample with the bale or bag from which it has been taken, and in doing so he looks at the sample and the general character of the cotton that the bale contains. In trying the staple of the cotton, he lifts a small quantity, and takes hold of it by the fore finger and thumb of the left hand, laying the cotton over the side of the fore finger, and then, by the thumb and fore finger of the right hand, he pulls out some of the cotton from the left, repeating this operation several times, until he has got an idea of the length and strength of the staple of the cotton. It will be obvious that this way of judging cotton is altogether a comparative one, for the person must have some knowledge of other cottons, before he can say whether the cotton he is looking at is of a good or bad quality. However, this method of judging cotton is the principal one resorted to by cotton brokers, and others engaged in buying and selling the article, and it is surprising how good judges some of them are, although

they know little or nothing about cotton spinning. However, the quality of cotton can best be tested after it has been made into yarn, by looking into all the processes through which it has gone, examining the staple, and looking into the different bales to see how they compare with the sample as regards dust, seeds, and dirt, and that there has been no false packing. If any of the bales are not up to the sample, they are put aside for further examination, and consideration as to what should be done with them. This is the time for trying the loss that is in the cotton, before the mixture is made up.

A certain quantity is taken, say fifty or sixty pounds, and put through the first machine, which may be the willow, or cotton opener. The inside of the machine is swept out before putting the cotton through, and, say that the quantity put through the machine is fifty pounds, the cotton is again taken and weighed, and the machine is again swept out, and all the dust, seeds, &c., that have come out of it, are collected and weighed, the dust by itself, the seeds or willow drops by themselves, and the cotton by itself, and these weights are entered in the loss book, opposite the mark of the cotton, so that, at any time, by looking at this book, it is seen what the first loss is in the different kinds of cotton.

After this examination is over, the different lots are weighed, to make up the heap, or bing.

MAKING UP THE MIXTURE.

The importance of this part of the process in cotton spinning can scarcely be overestimated. Upon it depends the quality of the yarn, and also the success of the business. Although the manual labour required in this process is of the most simple kind, yet the least negligence on the part of the worker may spoil the whole mixture, and, by so doing, damage the whole yarn spun from that mixing. If this were all the loss a bad mixture would lead to, it would be comparatively little—perhaps not more than the loss of the production of one day; but it is impossible to keep one mixture from being incorporated with the others, and the bad effects of the one may go on for weeks. The bad yarn gets mixed up with the good at the winding machine, also at the process of warping and a number of the bad threads may get into the chains or webs, and although the great bulk of the yarn that composes the chain is of the very best quality, the few threads give a bad character to the whole yarn. All weavers know how teasing it is to have twenty or thirty ends in their webs continually breaking, and all the rest of the yarn doing first-rate. It would be more profitable for the spinner, when he finds that a lot of inferior yarn has been spun, to give orders to winders, reelers, and warpers, to put aside any inferior cops, or bobbins, that they can detect;

and this inferior yarn could be warped by itself into chains, and these chains might be sold for purposes in which the inferior yarn would have no bad effect, such as cords for stuffing ladies' stays, co... cords, &c. It is a false idea of economy to think of putting in a few bobbins of the bad yarn into each warping, for the purpose of getting them worked up unnoticed. It would be more profitable for the master to make it into waste at once, than to use it up by mixing it with good yarn in that way.

It is to show the necessity of being careful in making up the heap, that I have made these remarks, and I will now state the way in which it is done. It depends upon the quantity of cotton the factory requires for a given time, what quantity of cotton should be put into one heap; for, if the factory is spinning a number of different kinds of yarn, and each kind requiring a separate mixture, then the space, that is at the command of the workman for making up the heaps, must be taken into consideration. But where it can be done conveniently, a large mixing should be prepared. Should the heap, when finished, contain two thousand pounds, and three different kinds or qualities of cottons, then, to illustrate the method of making up the heap, we will take nine hundred pounds of one quality, six hundred and fifty pounds of another, and four hundred and fifty pounds of another—in all two thousand pounds. The propor-

tions of these quantities are—for the nine hundred pounds, forty-five pounds; for the six hundred and fifty pounds, thirty-two and a half pounds; and for the four hundred and fifty pounds, twenty-two and a half pounds; which will stand thus—

1st.	900 lbs.	. .	45 lbs.
2nd.	650 lbs	. ...	32½ lbs.
3rd.	450 lbs.	. . .	22½ lbs.
	2000 lbs.		100 lbs.

Take three baskets, and, after finding the tare of each, put forty-five pounds in one, thirty-two and a half in another, and twenty-two and a half in a third. Take the three baskets to the place where the heap is to be made up, and throw in alternately into each basket (as near as can be guessed, the proportion of cotton contained in them) an armful of the cotton, into the place where the heap is to be made up, repeating this process until the two thousand pounds are made up. In this mixing there will be twenty weighings for each kind, and the person who weighs the cotton has a pencil, or piece of chalk, and for each weighing puts down a stroke, not depending on memory. This method of making up the heap is the most correct, although other methods are resorted to; but whatever way is adopted, it is most essential to have the cottons well mixed, and the weights of each entered in a book, which book will be taken notice of

along with the other books required for a spinning factory.

We have, in the foregoing remarks about the mixing of cotton, made our statements on the supposition that all the different kinds were ordinarily clean, and similar to each other as regards seed, dirt, and other extraneous matters; but it will be evident to any one who knows about cotton spinning, that if one lot of cotton is much fouler than the others, it would be very wrong to mix up in the heap the foul cotton with the clean. So, to prevent the seeds, &c., in the dirty lot from being incorporated with the clean, the foul cotton is put through the willow (or blower) by itself, before being weighed and put into the heap. Of course if all the cottons are equally clean, and free from seeds, &c., there will be no necessity for any of it being put through the machine, before making up the heap.

BLOWER OR WILLOW.

In the countries in which the cotton is cultivated for exportation, it is, as stated in the first chapter, gathered into baskets by the field workers, and taken to the place where it is to be packed into bales or bags. When it is put into bags it is only pressed down by the weight of the person who is packing the cotton, but, in most cases, it is packed in bales, and

highly compressed by mechanical power, to put the cotton into as small space as possible, for the purpose of making the charges for carriage less than when it is loosely packed. These bales are kept in their compressed state by iron hoops or ropes; the consequence is, that when it comes into the possession of the cotton spinner, and is opened, the cotton is found to be in hard matted lumps; so that the first machine the cotton is put through is partly for the purpose of breaking up these lumps. The machine, which has been long in use for this purpose, is called the Willow. Besides breaking up the hard pieces, it takes out a considerable quantity of seeds, and other extraneous matter from the cotton. The refuse thus taken out is called "willow drops," and is sold to the waste dealers, who re-sell it to others for various purposes.

The next, or second machine in the process, is one for still further opening up the cotton and cleaning it, and is called the Scutching machine. The cotton is taken direct from the willow, or cotton opener, to the scutcher, and put on the feed-apron, which carries it forward to the feeding rollers. It is at this machine that the remaining sand and seeds are nearly all taken out of the cotton, also the dirt or short light fibres. The cotton is separated by the repeated beating it receives, at the instant the cotton is delivered from the rollers. At the opposite side of the machine from the feeding rollers, the cotton is discharged in a loose

bulky state, ready for being taken to the spreading machine, which is the third in order. Its name is given from the fact that a given weight of cotton is spread out a certain length and breadth.

The spreading machine is the first where any attention is paid to the quantity of cotton to be put in for a certain length, and where the first notice is taken for the size of the yarn, although the quantity put through it, has very little to do with what numbers of yarn the cotton is to be spun into at the spinning machine. The workers that attend the spreading machine, are provided with a weighing apparatus, either the common beam and scale, or some other thing that will answer the purpose of weighing correctly. In general it is the beam, with a tin box at one end with the weight in it, that is to be used for weighing the quantity of cotton for one spreading, and at the other end a scale, or dish, sufficiently large to hold the quantity of cotton for a spreading. The tin box with the weight, is secured by lock and key, so that the worker has no access to it. The weigher must be very careful in giving the exact quantity of cotton to each weighing, and the spreader must also be careful in just giving the cotton the proper space on the table. If this is not particularly attended to, the bad effects follow in all the machines that the cotton has to pass through afterwards; and it is very troublesome, both to the carding and spinning master,

to keep to the proper standard that the roving and yarn should be when finished.

The weight of one spreading will depend upon the kind of machine, and the kind of yarn that is to be spun; and, as this is the first machine at which any attention is paid to the size of the yarn, I will explain how it is measured.

MEASURE FOR YARN.

All yarns have a certain standard by which they are measured, the principle being a given length for a given weight. The greater the length for that weight the finer the yarn. For cotton yarn, the length of the spyndle is 15,120 yards, the yard being 36 inches, and the spyndle is divided into 18 hanks or numbers, and it is from the number of these hanks, contained in one pound avoirdupois, that the size of the yarn is determined; so that when the yarn is said to be No. 20^{s}, there are twenty numbers or hanks in one pound; when No. 50^{s}, there are fifty hanks; No. 60^{s}, sixty hanks, and so on. For every hank more in the pound, one number finer.

The reel on which the yarn is wound is 54 inches in circumference, which gives one yard and a half, so eighty turns of the reel gives 120 yards. This 120 yards is called one skein. This is the first shift made by

the reel, and seven of these shifts give 840 yards, which is the number of yards that constitute a hank or number.

Both the carding and spinning master has a small reel, capable of winding seven threads at once. The carding master uses the reel for the purpose of testing the size of the rove, which he does several times each day, and very frequently when the sizes are not keeping steady; and the spinning master uses his reel for testing the size of the yarn. The usual way for finding the size of the yarn is, to take seven cops, or bobbins, as the case may be, and give the reel eighty turns. This will make one hank at once. There is a wheel attached to the reel with eighty teeth in it; this wheel gives an alarm when the reel has made eighty turns, or the finish of one hank. When it is desirable to be very particular, eighteen hanks can be reeled, which will make one spyndle. The spyndle for cotton yarn is divided as follows:

$1\frac{1}{2}$ yard,	one round of the reel.		
120 yards,	1 skein.		
840 yards,	7 skeins,	1 No. or hank.	
15,120 yards,	126 skeins,	18 Nos,	1 spyndle.

The measurements for linen yarn and some other kinds will be given in another place. We have given the measurement of cotton here, because it is at the spreading machine it begins.

Suppose that the weight of the cotton that constitutes one spreading be twelve ounces, and it be

spread on the table the full breadth of the machine, and in length thirty-six inches, and the speed of the circumference of the feeding rollers be represented by 2, and the speed of the circumference of the delivering roller be represented by 4, then the length of the lap will be seventy-two inches, and the weight of it twelve ounces (less the seeds, &c., taken out of the cotton by the spreading machine).

The delivering rollers are made sufficiently heavy, so as to give a pressure to the cotton that will hold it together in a firm state, to form a continuous web of all the different weighings of cotton that is to make up the full size of the lap. We have seen that one weighing gives seventy-two inches or two yards; and, if it take twelve of these spreadings, or weighings, to make one lap, then the length of the web of cotton will be twenty-four yards; and this is rolled up on a round piece of wood, the length of which is the breadth of the lap, and about one inch and three-quarters in diameter; this piece of wood remains in the centre of the cotton until the carding engine has finished the lap.

THE CARDING ROOM.

The carding engine is the fourth machine in the process of cotton spinning, and, in the generality of mills, the carding room is situated in the ground flat

of the main building. In modern cotton spinning factories, the main building consists of five or six flats, and varies in length and width, according to the kind and quantity of the machinery to be used in them. When it is principally mule spinning, the building is made very broad, for the purpose of getting in mules with a large quantity of spindles in each. This lengthening of the mule spinning machines, has been going on for the last thirty years, but whether the best length has been ascertained, has not yet been decided. After it was proved to be profitable to have long frames, the proprietors who had old narrow mills, so much desired to have them, that they put out the old mules, and put in new ones, placing them lengthwise in the building. It will be obvious, that, by having them arranged in that way, the light would, to a certain extent, be obstructed, and that was one of the reasons for having wide buildings.

From the picking house the laps are brought into the carding room, and it should be so arranged, that the taking of them from the one place to the other, can be done in the most expeditious manner. Some spinners have an underground passage, all lined with iron plates, and rails laid in it, for a carriage to run upon, conveying the laps from the picking house to the carding room. At each end of this passage, or tunnel, there is an iron door, for the purpose of preventing fire being communicated from the one place

to the other. These doors are made self-acting, that whenever the carriage passes, the door immediately shuts, and remains so until the reapproach of the carriage. Others have this passage above ground, in the most suitable place for the convenience of the workers.

When the lap is placed in the card, and properly adjusted, the worker puts the end of it to the fluted rollers, which take hold of the cotton, pulling it through; and, at the instant the cotton projects beyond the rollers, one of the card cylinders takes hold of it, and throws it against the tops, or other cylinders, as the case may be. By this means the cotton fibres are separated, partly stretched, and laid parallel with each other.

The rollers deliver the cotton to the first cylinder the full thickness of the lap, but at a comparatively slow motion, just allowing a quantity sufficient for the card cylinder to take up. When the cotton has got what is considered the requisite time for carding it, the doffer takes it, and the comb takes it off the doffer, and then it is contracted and pressed into the form of a ribbon. In this shape it is delivered into a long tin can, and is called a card end, or sliver. This is the point in the process at which the cotton begins to assume the appearance of anything like a thread. Although, as yet, it has no twist, it can be measured in the same manner as yarn, by taking a given number

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of yards and weighing it. If it is too heavy, the carding master can reduce its weight, by altering the speed of the feed rollers in the carding engine.

In factories where ordinarily fine numbers only are spun, the one flat of the main building suffices for holding all the carding engines, and the other machines that are used in preparing the rovings for the spinning machines; and the next machine that comes in order is the lapping machine (if there is double carding), but in the meantime I will pass it over without further notice, and proceed to the next, which is the drawing frame.

The cans that receive the slivers, or card ends, at the carding engines, are taken to the back of the drawing frame. The drawing frames are, in general, made with a number of heads—from three up to six—the number depending upon the quantity of doubling that is necessary for the yarn to be spun. Suppose that only one card's produce is put in the can, and four of these cans are put at the back of the first drawing frame, then the four card slivers are doubled and drawn, and delivered as one sliver into the drawing frame can. Four of these cans are placed at the second head, doubled, drawn, and delivered into a can as one sliver, which is equal to sixteen card ends, being doubled. Then, at the third head, the same is repeated with four cans from the second, which brings up the doubling to sixty-four. At the

fourth head the doubling is brought up to two hundred and fifty-six; and at the fifth head the doubling is raised to ten hundred and twenty-four, and so on, making it four times more each head, until the required amount of doubling and drawing is accomplished. If six card cans are put to the first drawing head, and the doubling carried on through the different heads until it reaches the fifth head, then the amount of doubling will be seven thousand seven hundred and seventy-six. After the sliver has passed through the last head in the drawing frame, the carding master sometimes tries the size of it, by weighing a given length.

It is in the process of drawing that the fibres of the cotton are more completely laid parallel with each other; for although, to a certain extent, they are straightened at the carding engine, many of them are not lying parallel until they are put through the drawing frame. Even after the process of the drawing frame, it will be seen, by examining the sliver, that a number of fibres are still lying crosswise, but these are partly put right in the next process, for which the slubbing frame is required.

The slubbing frame (sometimes called the slabbing frame) should be arranged in the carding room, in a convenient place near the drawing frames, so as the cans may be taken from the one machine to the other with the least possible trouble. It is at this frame

that the sliver (or card end) is reduced into roving, and where it receives a certain amount of twist. If only very coarse numbers are spun in the factory, the rovings are reduced to the size wanted for the spinning machines—either mule or throstle—and, when this is the case, the carding master has to be very particular in keeping the hank roving to the proper standard; for, if this is not done here, it cannot be corrected afterwards, except to a small extent by the spinning master, which is seldom satisfactorily done for various reasons, which it is not necessary to explain in this place.

When the slubbing frame has done its part, the rovings are taken to another machine, which is called the *intermediate fly, or "roving" frame.* In former times the slubbing machine was very different from what it is now, and, since the spindle and fly have been introduced for the preparation of roving, the slubbing has been done in what is styled the fly frame, the only difference between the slubbing and roving frames being the difference in the size of the spindle and fly. The intermediate frame receives the slubbing on large bobbins, and the use of it is to draw out the roving into a finer size, preparatory for the next machine, which is the finishing fly frame.

The name "finishing fly frame," is given to this machine because it gives the last drawing and twist to the rove, previous to it being sent to the spinning

machines. By having too much draught at any single drawing, the yarn is spoiled. Therefore, the card end, which must be a certain thickness to enable it to bear its own weight, has to be reduced at different stages, and, although the drawing frame reduces it considerably, it does not bring it down very fine, because, the sliver having no twist, it must be kept sufficiently thick to sustain its own weight, and it is only after it comes to receive twist (when it is called "slub" or "rove") that it can be brought down to any degree of fineness; and for very fine numbers this must be done at different stages, hence the necessity for having two, three, or four machines, for reducing the roving, after it has received a certain amount of twist. It is at this last frame, after the rove has been to some extent twisted, that the carding master has to produce the proper standard of hank roving, for the numbers of yarn that are to be spun from it, and it is from this standard, that the spinning master is enabled to calculate the draught that will be required to produce the given fineness of yarn.

The rovings, that are made by the "finishing fly frame," are taken from the carding room to the spinning flat, which is generally the floor above the carding room. There are different methods of carrying the rove to the spinner. Some have hoists for that purpose, and the baskets, or boxes, with the rove, are taken up from the ground floor to any of the

other rooms as may be required. Some still employ boys to carry the boxes; but, in whatever way it may be done, it is requisite that care be taken not to spoil the roving in transmission.

If the spinning machines are throstle frames, the worker puts the rove in, and attends to the cleaning and piecing of ends, no other worker being required to keep the machine going, except the person who ties the bands, and repairs any little thing that may go wrong. In some factories a number of boys or girls are kept for doffing the bobbins when they are full. In other factories the spinner takes off the full bobbins, just as they are required, without the aid of any other person; so that throstle spinning, so far as workers are concerned, is a very simple process, but one that requires constant attention, so as not to allow any of the ends to remain broken, or what is called in the trade "the ends down."

When it is mule spinning, either self-acting or hand, there are little boys or girls that are called rove piecers, and they carry the rove to the spinning machines, and put it in at the back of the mule; the other workers, being at the front, piece the broken ends. The yarn is built on the spindles in the form of a cop, and when the full quantity of yarn to finish the cop is spun, they are taken off all at the same time, and a new set begun. It is different with the throstle, as one bobbin may be empty, one half full,

and the others at all the different stages between empty and full,—while with the mule they must all begin and end at the same time.

Although a great quantity of mule yarn is built on the bare spindles, it is not the universal plan; for pirn cops, and also large cops, are spun on paper tubes, and some on tubes made of cloth, and, if the yarn is to undergo a process of bleaching or dyeing, while it is still in the form of a cop, a tube made of a substance capable of standing the particular process is used for building the yarn on. A number of these tubes are made of wood, others of tin plates, sheet-brass, copper, &c. When the long tubes were introduced, a little inconvenience was experienced by the spinner when in the act of beginning to put in the draw, or what is called, stripping the spindles. This, however, was soon got over, and the building of the yarn on long tubes, is rapidly getting into favour with those who use the yarn.

The spinning master tries the size of the yarn, several times each day, by taking a sample from each system (a number of machines spinning the same kind of yarn, are, taken collectively, called "a system"), of which there may be several in one room; and the results of these trials are entered in a book kept for the purpose.

The yarn, when spun, is taken to what is called the wareroom or warehouse, which, in well-constructed

factories, is a building by itself, having connection with the main building, or it may be situated in a wing of the mill. It is requisite to have as much space in the warehouse as will enable the person, who takes in the yarn from the spinners, to keep each spinner's produce by itself. The number of the worker or machine is marked on a slip of paper, which is attached to the yarn. By having the yarn numbered in this manner, the manager is enabled to trace back any faults that may be found with it In some mills the warehouse is sufficiently large to allow of the bundling being carried on in it. Bundling is the process which follows reeling.

If the factory is one that has no spinning but that of the mule, and the proprietor sells all his yarn in cop, no other machine is required, the cops being packed into baskets or boxes, and delivered to the yarn merchant in that state; but if the yarn is to be sold in bundles, the warehouseman sends it out to the reelers. The reeling room is generally near the warehouse, in the same building. Reeled yarn is put up in ten or five lb. bundles, and the size of the yarn regulates the number of hanks to be put in each bundle. The reeler is told this number, and the quantity is counted when she is stripping the reel of the yarn. It is taken back to the warehouse in five or ten lb. bundles, ready for the person whose work it is to sort and pack it in the machine called the

bundling press. When it is papered and marked it is ready for the merchant.

When the yarn is to be sold in chain, or on beams. After it comes into the warehouse from the spinner it is delivered to the winders. The winding machine is the one that puts the yarn on large bobbins for the warper. It may be wound on these bobbins either from the cops or the small bobbins that are used at the throstle frame. The winding and warping machines are generally in the same compartment, and the bobbins are taken from the winding to the warping machine, and as many placed in the bank of the warping machine, as will make up the number of ends required for the intended web. After the warper has wound on the beam the requisite length, whatever that may be, a lease is taken, and that warping is finished. But if the yarn wound on the beam is intended for a "chain," three or four thousand yards long, the warper puts a lease cord in at the finish of every five or six hundred yards. These lease cords are put in to enable the beamer to correct any damage that may occur to the chain in the process of bleaching or dyeing. If this is not done, and the yarn gets torn, it is very difficult to get the threads of the chain put into their proper places again.

In taking the yarn off the warper's beam to form the chain, it is very important that it should be taken off evenly, that is, that one thread shall not be tighter

than another. This is accomplished by having the warper's beam placed at least thirty feet from the point where the yarn is contracted into the rope shape. Before chaining machines were introduced, the yarn was put up into loops—hence the reason for calling it a chain; but the machine that takes the yarn off the warper's beams, does not put it up in links or loops, but lays it down in a box large enough to hold the longest chain. After this process the yarn is ready for delivery to the weaver or yarn merchant.

THREAD.

A number of plies of yarn twisted together, whether the yarn be made of cotton, flax, silk, or worsted, is called thread. Although very little is made of worsted yarn for sewing purposes, it is made largely for other things. It is the particular way in which it is twisted, that constitutes it thread, irrespective of the material from which it is spun.

Some spinning mills are principally employed in producing yarns suitable for thread making, either for sewing purposes or for net making. This class of yarns is generally of a superior quality. They are made from a higher priced cotton than the common yarns, and more attention is paid, in the preparation

department to the cotton, before it reaches the spinning machines.

If the yarn is spun with the throstle frame, it is all reeled in the common way, and sold to the thread manufacturer in bundles. In that state it is ready to be sent out to be bleached, or dyed, according to the kind of thread that is intended to be made. If it is mule yarn, the thread manufacturer sometimes gets his yarn in cops. When this is the case, it is either wound on bobbins or reeled.

In the factories in which all the processes of thread making are carried on, the following machines are required. I will merely take notice of them here, as they will be explained in another chapter. They are: reels, winding machines, warping machines, twisting frames, polishing machines, doubling machines. There are also machines for putting the thread on the bobbins, besides balling machines, turning lathes, and machines for making the bobbins. The reels are for putting the yarn into hanks, either before it is made into thread, or afterwards. Winding machines are required for putting the yarn on to large bobbins, either from the cop or hank. There are two kinds of winding machines, one for winding from the cops or small bobbins, and one for winding the yarn from the hank. The hank winding machine can either wind from cops, bobbins, or hanks; but the cop winding machine can only wind from bobbin and cop. The

hank winding machine is much higher in price than the other, and takes up more space, hence the reason for having both kinds.

At the early period of thread making, warping machines were not required, but by the improvements that have been introduced into the business, they are used in all large establishments. When a given quantity of thread is to be made of a certain kind, that quantity is warped upon a beam, and then it is made into a chain, and sent to the dyer or bleacher, as the case may be, instead of being sent in hank. It is also warped on the beam, for the purpose of being sent to the polishing machine. This polishing machine is a recent invention, at least in its present form, but there was machinery for dressing and smoothing the thread many years before the present machine was introduced.

The machines for twisting the yarn into thread are of two kinds. One of them is similar to the mule in many respects, the principal difference being in the rollers. Instead of having rollers for drawing the cotton out to its proper size, as in the spinning mule, there is only one roller in the mule that is used for twisting the yarn; and, in place of the rove being in the creels, the bobbins with the yarn that is to be twisted is put into them. The other machine that is used for twisting, is very similar to the throstle frame, and the yarn that is twisted in this machine for thread,

is very superior to that done in the machine like the mule, being more regular and firmer in the twist. In the machine like the throstle, the rollers that regulate the speed of the yarn while being twisted, are covered with brass, or some other material that will not rust by being in contact with water, most sewing thread being taken through water immediately before it is twisted.

In a number of the factories in which thread is made, instead of putting only one ply of yarn on the large bobbin that is to go to the twisting machine, there are two, three, or four single ends, wound on the bobbins that are put in the twisting frame, and it is at the doubling machine that this is done. If four plies of yarn is being wound on a bobbin, and one of the ends break, or is awanting, it would not do to allow only the three ends to run on to the bobbin without the fourth; and, to prevent this, there is a very nice piece of mechanism, attached to each place where the bobbin is being filled, that instantly stops the winding whenever one of the ends are away.

At one time, sewing thread was largely sold in "balls," and these were built up very neatly with a little apparatus called the balling machine, but they are now, to a great extent, superseded by the thread being sold in "spools," or small bobbins, and the thread manufacturers have machines for the purpose of winding the thread upon these bobbins, by some

called "spooling machines." The small bobbins were all made by the wood-turners, until the time when machines were introduced for making them. The bobbins being made at very little cost, the manufacturers were enabled to sell a greater length of thread at a given price, than when the bobbins were made by the wood-turner, and this encouraged the consumers to get their thread upon the bobbins, instead of buying it in balls, consequently a great many balling machines were thrown idle.

When the merchant or shopkeeper bought his thread in balls, he could easily ascertain if he were getting full value, because the "balls," being built on a bare spindle, when it was finished, there was nothing but thread in it, and by weighing them, the buyer knew exactly the quantity of thread he was paying for; but when the thread is wound upon bobbins, it cannot be ascertained what quantity the bobbins contain. Of course the length of thread that is marked on the ticket should be on the bobbin, but that gives no idea of the value, for there are so many different sizes or "numbers," that the length does not give even an approximation to the value; therefore, the buyer must depend upon the maker and merchant, to give value for the money paid.

It is a very particular job, the winding of the thread upon the small bobbins that are sold with it. The machine for doing it is a very nice combination of

mechanical movements compactly put together. One of the motions is the turning of the arbour where the empty bobbin is put on, another is for the guide that causes the thread to traverse from the one end of the bobbin to the other. This guide must increase its traverse for every layer of thread that is put on the bobbin, as all the ends of the bobbins are bevelled, and the motion of the guide must be made to correspond to the thickness of the thread. For coarse thread the guide moves at a greater speed the distance it has to travel, than what it requires to do for the fine numbers, and this movement is graduated by the pitch of the screw that works the guide, or it may be done by change pinions.

After the bobbins are filled with thread, they are labelled on the ends, to show the length in yards, and kind of thread they contain. The machine has an index attached to it, to show the length of thread that has been wound on the bobbin.

CHAPTER IV

PREPARING FOR MAKING YARN.

We will suppose that the factory is built, and that the motive power is a steam engine; and, to illustrate the finding of the speeds for the different shafts, we will suppose that the main shaft of the steam engine makes twenty-five revolutions per minute.

When the speed of the first shaft is ascertained, the next thing to know is the number of teeth in the driving wheel, that is the wheel on the crank shaft of the engine, be it either a spur or a bevel wheel; and say the number of teeth is one hundred and twenty in the driving wheel, and it is geared with a pinion that has forty teeth. Multiply the revolutions of the crank shaft by the number of teeth in the driving wheel, and divide the product by the number of teeth in the pinion; and the answer is the number of revolutions the second shaft will make per minute; which will be seen from the following calculation to be seventy-five revolutions per minute:

EXAMPLE No. 1.

```
        The crank shaft makes    25 revolutions per minute.
Number of teeth in driving wheel, 120
                                 ---
                                 500
                                25
                                ----
Number of teeth in pinion, 40)3000(75 speed of second shaft.
                              280
                              ----
                               200
                               200
                               ---
```

This second shaft is, in general, the shaft that conveys the power from the engine to the upright shaft of the spinning mill or main building; on the end of it is a wheel with sixty-four teeth, gearing with another wheel on the lower end of the upright shaft which has forty-eight teeth; and this gives a speed to the upright shaft of one hundred revolutions per minute.

EXAMPLE No 2.

```
        The second shaft makes   75 revolutions per minute.
Number of teeth in driving wheel, 64
                                 ---
                                 300
                                450
                                ----
                             48)4800(100 speed of upright shaft
                                48
                                ---
```

The speed of all the other shafts are found in the same manner: always multiplying the teeth in the driving wheel by the number of revolutions made by the driving shaft, and dividing by the teeth in the driven pinion (or wheel) for the speed of the driven

shaft. The driven shaft, sometimes, also becomes a driver, but this makes no difference in the mode of calculation. But suppose that the upright shaft was to be driven at one hundred and two revolutions per minute, the pinion that would come nearest, to give that speed, would require to have forty-seven teeth, and the calculation would be as follows:

EXAMPLE No. 3

The second shaft makes 75 revolutions per minute.
Number of teeth in driving wheel, 64

300
450

Number of teeth in pinion, 47)4800($102.127\frac{31}{47}$ speed of [upright shaft.
47

100
94

60
47

130
94

360
329

.31

.47

Take the speed of the upright shaft at one hundred and two revolutions per minute, and the bevel wheel that is on it for driving the shaft leading into the flat to have fifty-eight teeth, and this shaft leading into

the flat requires to be driven at one hundred and sixteen revolutions per minute. What is the number of teeth that the pinion will require to have, to give the speed of one hundred and sixteen?

As in the former example, the speed of the shaft is multiplied by the number of teeth in the driving wheel, but instead of dividing the product by the number of teeth in the pinion, it is divided by the number of revolutions that are required for the driven shaft to run at.

EXAMPLE No. 4.

```
            Speed of upright shaft,  102  revolutions per minute.
Number of teeth in driven wheel,      58

                                     816
                                    510

 Speed of leading-in shaft, 116)5916(51 number of teeth for
                                580                  [pinion.

                                 116
                                 116
```

In trying to find the proper number of teeth in any wheel or pinion, sometimes there will be a fraction over, and in that case the one nearest to what is wanted is selected.

When it is necessary to change the position of any of the shafts by making the one run at right angles to the other, this is done by bevel wheels, and the cal-

culations are made in the same way; but if the wheels are what is called "mitre," there is no use in taking any notice of the number of teeth in them, as, both being the same diameter, the speed of both shafts is the same.

The mode of calculation made use of for wheels is the same as that used for drums and pulleys, where belts are made the means of conveying the power from one point to another instead of shafting; but, in place of taking the number of teeth, the diameter of the pulley in inches and fractions of an inch is taken. When the name "drum" is used, it just means a pulley that is both large in diameter and broad on the face; the pulleys that are fixed upon the shafting for driving the different machines are, by the operatives, generally called "drums," in contradistinction to the pulleys that are on the machines. They are all called pulleys by the millwrights.

WILLOW AND COTTON OPENER.

The shaft that conveys the power into the preparation room or picking house, may run at a speed of two hundred revolutions per minute, and the speed of the willow will depend upon the diameter of its cylinder. If the cylinder is three feet in diameter, the

number of revolutions it should make per minute will be two hundred and seventy-five, and with a pulley on the axle of the cylinder fifteen inches in diameter, (the pulley should not be less than this, as the willow is a machine that requires a considerable amount of power to drive it); the driving pulley on the shaft will require to be twenty inches and five-eighths to give the speed that is wanted for the willow.

EXAMPLE No. 5.

```
Speed of leading-in shaft,        200
Diameter of driving pulley,    20.625
                               ------
                                 1000
                                 400
                               1200
                              4000

* Pulley on willow, 15)4125.000(275 revolutions of willow per
                       30                            [minute.
                       ---
                       112
                       105
                       ---
                        75
                        75
                        --
```

The following example shows how the diameter of the driving pulley is found. When the speed of the machine, and the number of revolutions the driving shaft makes, are known, multiply the speed of the machines by the diameter of its own pulley, and divide the product by the speed of the driving shaft.

EXAMPLE No. 6.

Speed of machine, 275
Diameter of pulley, 15

1375
275

Speed of driving shaft, 200)4125(20.625 or 20.$\frac{5}{8}$ inches in diameter
400 [of driving pulley.

1250
1200

500
400

1000
1000

The common willow is a very simple machine, consisting of a cylinder made of three cast iron rings, keyed on to a shaft which forms the axle of the cylinder, and it is on this shaft that the fifteen inch pulley is fixed; and on these cast iron rings are bolted staves of wood, about three inches thick, and about five or six inches broad. In these staves the spikes are made fast. The spikes are made to project above the wood about five inches, and are slightly tapered and pointed at the ends. There are two cast iron sides which form the framing of the willow, and are made with a curvature at the top to suit the circle of the cylinder, and this part is filled with spikes inside the curve, similar to those in the cylinder, and pointing towards the axle of it. The spikes are

placed in rows about six inches apart, both in the cylinder and the cover, and are so set that those in the cylinder will pass between those in the cover. At one end of the machine there is an opening through which the cotton is put, and at the other end another opening to allow the cotton to fly out, after it has been the requisite time in.

The use of the willow, as I have noticed before, is to open up the cotton, in preparation for the next machine; so, it should be placed in the picking house, convenient to the cotton that is to be put through it. The spikes should not be set too close, as they will have a tendency to tear the staple of the cotton if they are so. The worker that feeds the machine should be careful not to give it a great quantity at one time, as a heavy feed is apt to choke it, and break the spikes; neither is it well to allow the cotton to remain long in, it being better to feed light and often. There is a door for closing the opening, which is at the opposite end of the machine from that at which the worker puts in the cotton. This door is connected to the end of a lever, the fulcrum of which is in its centre—the other end projecting in front of the machine, so that it can be acted upon by the worker's foot. When the machine is put in motion for working, a certain quantity of cotton is put in it; and, when it has remained in the proper time, the worker depresses the lever with her foot, which causes the door to open,

and the cotton flies out at the opening. As soon as this is done, the willow is ready for another feed.

Besides opening out the lumps of cotton, the willow takes out a considerable quantity of sand and seeds that are mixed up with it. Before the willow was introduced into the cotton spinning trade, the cotton was teased out by hand, and some consider that this is the best way still for very fine numbers. The mode of doing it was as follows:—A wooden frame, six feet long by three feet broad, made in the form of a common table without the top, but instead of the top there is a series of cords stretched lengthwise on the frame. The cotton is laid upon these cords, and spread out by the hands, and then beat with scutchers, causing the sand and seeds to separate from the cotton and fall down between the cords. There is no doubt about this being the best way of teasing and cleaning the cotton, for the worker can make it all perfectly clean and open, before it is removed from the table; but it is a very expensive mode, and it would never do to apply it to any kind of cottons but those used for spinning high-priced yarns.

There is another machine called "a cotton opener," used, as its name implies, for opening up the cotton, and taking the seeds and sand out. This machine, unlike the willow, stands perpendicular, and has a shaft about three inches in diameter, and about six feet long; and round this shaft is fixed a number of

iron spokes which are in the form of a double backed sword, and they are placed round the shaft, forming a scroll. This shaft runs in the centre of the machine in a perpendicular position. The cotton is put into the opener at the top, and, as it falls down, the blades on the shaft beat it. The fall of the cotton is accelerated by a current of air rushing in at the top of the cylinder, and escaping at the bottom. The current is caused by a fan. Some spinners like this machine very much for opening up the cotton, others object to it because it does not take out the seeds so well as they would wish, and in some places both it and the willow are used.

THE SCUTCHING MACHINE.

This machine is one that was introduced for the purpose of superseding the scutching of the cotton by hand. It was first tried at Johnston, and the inventor of it was Mr. Neil Snodgrass. It served the purpose so well, that it soon came to be used in almost all the spinning mills, except those that spun very high-priced yarns. A number of alterations, and some improvements, have been made on these machines since they were introduced. Even the name has been changed, in some instances, where the alteration or improvement has been very observable; but, in all, the intention was to make the cotton fibres as loose

and open as possible, before it was taken to the machine that was to make the lap for the carding engine.

The scutching machine should be placed in the picking house, convenient to the willow or cotton opener, as the cotton is taken direct from the place where these machines deliver it, to the scutcher. At the end of the machine there is a revolving apron, which is kept in motion, and to the proper degree of tension, by two rollers, which are made either of wood or iron. These apron rollers receive their motion from the feeding rollers of the machine. On this apron the worker spreads the cotton, which is by it carried forward to the front of the machine, when the feeding rollers take hold of the cotton and pass it through to the beater (or scutcher), which, being driven with very great velocity, beats the cotton so thoroughly, that it causes the fibres to open out, and part with most of the seeds and sand that were left in it by the other machines.

It will depend upon the diameter of the scutcher at what number of revolutions per minute it should be driven. It is considered that it attains a good speed when it goes at the rate of six thousand three hundred feet per minute. If the diameter of the beater be twenty-one inches, its circumference will be sixty-six inches, or five and a half feet. The three thousand three hundred, divided by five and a half, will give the number of revolutions per minute for the scutcher,

which will be found in the calculation to be one thousand one hundred and forty-five.

To find the circumference from the diameter, multiply the diameter by twenty-two, and divide the product by seven.

EXAMPLE No. 7.

$$
\begin{array}{lr}
\text{Diameter of scutcher,} & 21 \text{ inches.} \\
 & 22 \\
\hline
 & 42 \\
 & 42 \\
 & 7)462 \\
\hline
\text{Circumference of beater,} & 66 \text{ inches, or } 5\tfrac{1}{2} \text{ feet.}
\end{array}
$$

$$
\begin{array}{lr}
\text{Speed of beaters per minute,} & 6300 \times 2 \text{ feet} = 12600 \\
\text{Circumference of beaters,} & 5\tfrac{1}{2} \times 2 \text{ feet} = 11 \\
 & 11)12600 \\
\hline
\text{Revolution per minute,} & 1145\tfrac{5}{11}
\end{array}
$$

The speed of the shaft, which conveys the power into the picking house, being two hundred revolutions per minute, and say the pulley on the end of the scutcher, for driving it, is eight inches, and that the number of revolutions it is to make should be about eleven hundred and forty-five, it is obvious that an intermediate shaft will be required to bring up that speed. If a pulley, thirty inches in diameter, be put on the shaft that is running at two hundred revolutions, and that pulley driving one fifteen inches on the intermediate shaft, that shaft will run at four hundred.

EXAMPLE No. 8.

Leading-in shaft,	200	revolutions.
Driving pulley,	30	inches.

Diameter of driven pulley 15)6000(400 speed of intermediate [shaft.
60
000

The speed of the intermediate shaft being four hundred, with a pulley on it for driving the scutcher of twenty-three inches, then the speed of it will be eleven hundred and fifty revolutions per minute.

EXAMPLE No. 9.

Speed of intermediate shaft,	400
Diameter of driving pulley,	23
	1200
	800
Pulley on end of scutcher,	8)9200
	1150 speed of scutcher.

The circumference of the feeding rollers and the apron should go at the same speed: that is, they should go through a given space in a given time; for if the apron went at a greater speed, the cotton would be unduly pressed up against the rollers; and if they went more slowly, the rollers would draw the cotton too far in, and cause an unequal delivery of the cotton to the scutcher. When there are more scutchers than one in the machine (and, in general, there are more, some of them having four), the speed of the first

feeding rollers are made to go much more slowly than the others. A good average speed for the first apron to go at is ten feet per minute; and, if the feeding rollers be two inches and seven-eighths in diameter, and that their circumference should go at the same speed as the apron, the number of revolutions the roller will make in a minute will be fully thirteen, as will be seen from the following calculations:—

EXAMPLE No. 10.

To find the circumference of the roller, the diameter of which is $2\frac{7}{8}$ or 2·875.

```
   2·875
      22
   -----
    5750
   5750
  ------
7)63250(9·035 circumference.
  63
  --
   25
   21
   --
    40
    35
    --
     5
     -
     7
```

Divide the ten feet (which are 120 inches) by the circumference of the roller for the number of revolutions that they make per minute:—

EXAMPLE No. 11.

```
Circumference of roller, 9 035)120·000(13·28 speed of roller.
                             9035
                             ----
                             29650
                             27105
                             -----
                              25450
                              18070
                              -----
                               73800
                               72280
                               -----
                                1520
                               -----
                               9 035
```

The speed of the other rollers can be found by the same rule.

When the cotton has passed the first scutcher, it falls on the second apron, and is conveyed forward to the second pair of rollers. The speed of this second apron may be about sixteen feet per minute; the third (if there is a third in the machine) should be twenty feet; and the speed of the fourth apron should be twenty-four feet. These aprons were usually made of cloth; but now, many of them are made of three or four leather straps, running longitudinally with the machine, and on to these straps are riveted small slips of wood, with a space between each slip about a quarter of an inch wide. These openings allow the sand and small seeds to fall down.

The reason for driving each successive pair of rollers faster than the pair immediately before is, that

the cotton may be delivered to the scutcher in a thinner layer; and the beating of it may be increased by having three blades in the second scutcher, and four in the third and fourth; or the beating may be increased by driving the scutcher itself at a quicker speed. But it is not advisable to drive the scutcher at a very high speed: it is better to increase the blades in them, which answers the same purpose. Some of these machines have got a revolving cylinder, the circumference of the cylinder being made of perforated sheet iron; and a vacuum is, to a certain extent, formed inside the cylinder by using fans for that purpose The consequence is, that the cotton is driven towards the cylinder by the force of the current, and the sand and small seeds are driven into the inside of the cylinder through the small holes that are in the sheet iron covering, and the cotton is carried forward to the next pair of rollers.

With these additional appliances to the scutching machine, the name "Blower" is given to it by some machine makers. The machine is covered all over the top, and also the sides of it are enclosed, so that the cotton is kept within the limits of the machine, although blown about in all directions inside, until it is put out at the other end of the machine, where it is delivered into a large basket by a pair of rollers, which rollers compress it a little when in the act of passing between them. The

machines that have been made for opening up and spreading the cotton are numerous, and their mechanical construction very various. One kind is made that serves the purpose of an opener, a blower, and also of a spreading machine—the lap for the carding engine being made at the same time. But this machine is not approved of by spinners who are particular about the quality of yarn they spin. Sometimes the laps that are made in these machines are not taken direct from them to the carding engine, but are taken to another machine, which still further cleans and loosens the cotton, and makes the "finishing lap" for the card, which lap is, in general, made by the spreading machine; and I will now proceed to give a description of it.

SPREADING MACHINE.

When the cotton has been opened up and cleaned by the willow and the scutching machines, it is ready for being made into a lap, preparatory to it being carded; and it is the spreading machine which is used for that purpose, although some have adopted the plan of making the lap at the scutching machine, and, when that is the case, the spreading machine is dispensed with.

Previous to the invention of the spreading machine, the laps, after the cotton was opened up and cleaned, were made up by spreading the cotton on a piece of cloth with the hands. The cloth that the cotton was spread

upon was the same breadth as the lap, and ten or twelve feet long. A given weight of cotton was spread on this cloth all at equal thickness, and afterwards rolled up, cloth and cotton, into what was called the lap, and, when put to the carding engine, the cotton went through between the feeding rollers of the card, leaving the cloth to drop on the floor, and, when all the cotton was taken in by the card rollers, the cloth was removed to form another lap.

The spreading machine should be set down in the most convenient place in the picking house, so as to suit the driving shaft, and also to be as near as possible to the scutching machine, so that the carrying of the cotton from the one machine to the other will be done with the least labour; and as it is from this machine that the laps are to be taken to the carding room, provision should be made that they may be removed without any unnecessary loss of time.

In arranging the machines in the picking house, the tradesman who has charge of fixing them down to the floor cannot be too particular in having the machines properly set. The first thing he should do is to get a plummet (sometimes called plumb) and line, and apply it to the driving shaft—first at the one end, and then at the other—and, where the point of the plummet touches the floor, make a mark, and then take a straight-edge sufficiently long to touch the two plummet marks, then make a mark with a draw-point on

the floor, along by the straight-edge. This line will represent the position of the driving shaft; and from it all the measurements for the setting of the machines can be taken. In placing the willow, the measurement can be taken from the centre of the axle of the cylinder, to set it parallel with the line of the shaft. and a spirit-level applied to the journals will serve for the purpose of getting it properly adjusted. A piece of wood or leather can be put under the feet of the lower side of the machine, of a thickness sufficient to bring it up to be on a level with the other side. This is all that will be required for the willow.

It will be rather different in setting the scutching machine, it being driven by the small intermediate shaft; but the mode of procedure is the same. Of course, the intermediate shaft should be parallel with the other shaft, and it may be unnecessary to mark the line of it on the floor. In that case, the measurements can be taken from the line that was drawn for the willow. The rollers and the scutchers in the machine will be all parallel to each other (at least, they should be so), and taking the measurement from one of the scutchers and the line of the shaft will be sufficient to guide the workmen in placing the machines parallel with the shaft that drives them; and, by taking the journals of one of the scutchers, for the levelling of the machine, he will get it properly set. Once he has got one scutcher right, he can examine

the others, by measurement, to see if they are right, also. If any of them be off the line of the shaft, the belts will not run properly, and will be a constant annoyance to the workers, by coming off. If the plummer blocks for the scrutchers are not cast on the framing of the machine, they can be shifted, so that they will be all parallel with one another.

The rollers for feeding-in the cotton to the different scutchers should be parallel with the scutchers, and, as nearly as possible, on the same level with them—the rollers being two inches and seven-eighths in diameter, there will be no danger of the blades of the scrutcher breaking the fibres of the short staple cotton, although the scutchers be set so close to the feeding rollers as just to run clear of them; but, for cotton that has a long staple, the rollers must be set as far off the scrutcher as will prevent the longest fibre from being torn by it.

The wooden or iron rollers that are used for driving the aprons are also to be set parallel with each other, and with the feeding rollers. The roller next those for feeding is placed a few inches higher than its neighbour, so as to give the apron a certain amount of incline. These remarks about the setting of the different parts of the scutcher apply to the spreading machine also. The spreading machine aprons are similar to the aprons used in the scutching machine, except the one that is in front of the spreading machine, it being made about double the length,

for the purpose of enabling the worker to get the cotton properly spread on it. This apron is divided into so many spaces, by black marks across the apron from one side to the other, and it is between these black marks that a given weight of cotton is spread; and this spreading of a given weight into a given length is the commencement of measurement for the yarn. It is most essential that the worker whose duty it is to weigh and spread the cotton at this machine be very exact both with the weighing and spreading of the cotton. Because, if the laps are unevenly made, there must of necessity be uneven carding; and I have already pointed out the bad effects that arise from any carelessness with this part of the process.

As the worker spreads the cotton on the apron, it is, at the same time, moving towards the rollers, and they take hold of the cotton and put it into the scutcher (or beater). If, from any cause, the machine has taken the cotton in faster than the worker could spread it, and the worker sees that, the machine should instantly be stopped, and not put on again until a fresh spreading is put upon the apron; for, if this is not done, there will be a break in the lap, which will also cause a damage to be in the carding. When things are going right, there should be no stopping of the machine. If the speed of it is too great for the workers to keep it regularly going, then the speed

should be reduced, or workers more expert at the weighing and spreading procured, who will be able to keep the machine running regularly.

When the cotton has passed between the rollers and been scutched, it falls on to a revolving apron inside the machine, and this apron carries it forward to what are called the calender rollers. Before the cotton has reached the calender rollers, it has been very much opened up, and its fibres loosened; and these rollers are for the purpose of making the fibres cohere, so as the lap will be more easily made, and that the one layer of cotton will part with the other at the carding engine. Although the cotton is spread a certain thickness before entering the machine, it is not necessary to keep it to the same thickness when delivered by the calender rollers to form the lap; and this will depend upon the speed between the feeding rollers, and the rate at which the cotton is delivered by the calender rollers. Of course, the calender rollers cannot put out more cotton than the feeding ones put in; but they may deliver a greater length from one pound of cotton than what the one pound was spread out at before it entered the machine; or a shorter length may be delivered than the length put in; but, in general, the length of what is delivered is longer than what the same weight of cotton was spread at, which will appear when we give the speed of the machine.

The speed of the beater (or scutchers) in the spread-

ing machine, should be about the same as the first beater in the scutching machine, which is six thousand three hundred feet per minute; and a common size for the diameter of the scutcher in the spreading machine is eighteen inches. I have shown how the number of revolutions are to be found from the diameter before, and found, in that case, that the pulley required was twenty-one inches. So that if a twenty-one inch scutcher requires eleven hundred and forty-five revolutions per minute, to give the six thousand three hundred, what number will an eighteen inch scutcher require? This will be found by simple proportion, thus:

EXAMPLE No. 12.

21 : 1145 :: 18
21
———
1145
2290

18)24045(1335.83, or $\frac{15}{18}$, say 1336 revolutions per minute [for scutcher.
18
———
60
54
———
64
54

105
90
———
150
144

60
54

6

The speed of the shaft for driving the spreading machine being four hundred revolutions per minute, and it being required that the scutcher shall run at thirteen hundred and thirty-six revolutions per minute, what will be the diameter of the driving pulley to give that speed? The pulley on the scutcher being eight inches, multiply the speed of the scutcher by the diameter of its pulley in inches, and divide by the speed of the driving shaft.

EXAMPLE No. 13.

```
        Speed of scutcher,          1336
Diameter of pulley in inches,          8
                                   -----
           Speed of shaft,     400)10688(26·72 diameter of pulley.
                                    800
                                   -----
                                    2688
                                    2400
                                    -----
                                     2880
                                     2800

                                       800
                                       800
```

Suppose the gearing all put up, with the proper size of pulleys, and the machines all set, find the speed of the scutcher in the spreading machine from the speed of the shaft conveying the power into the picking house, which speed we have stated, at page 119, to be two hundred revolutions per minute.

EXAMPLE No. 14.

Speed of the shaft for picking house, 200
Diameter of pulley in leading-in shaft, 30

Diameter of the driving pulley, 15)6000(400 speed of interme-
60 [diate shaft.

The speed of the intermediate shaft being four hundred revolutions, multiply this four hundred by the diameter of the pulley on intermediate shaft.

EXAMPLE No. 15.

Speed of intermediate shaft, 400
Diameter of pulley on intermediate shaft 26·72

800
2800
2400
800

Diameter of pulley on scutcher, 8)1068800(1336 speed of scutcher.

26
24

28
24

48
48

The speed of the feeding rollers may be about nine feet per minute—that is, the space that the circumference will go through in one minute; and, of course, the apron upon which the cotton is spread must go at

the same speed. I have already given the rule, how to find the number of revolutions the rollers should make per minute, to give the required speed for their circumference; and the speed of the calender rollers is found by the same method. The calender rollers being, in general, larger in diameter than the feeding rollers, their circumference must be taken into calculation when tracing the speeds.

There is a difference of opinion among spinners about the speed of the calender rollers, compared to the speed of the feeding ones; but it is evident, that by making the feeding rollers go more slowly than the calender ones, it will give the worker, who spreads the cotton, more time to spread the quantity for one lap, because the given weight that is to constitute the lap is spread over a shorter distance. This plan of spreading heavy is sometimes carried to such an extent, that the length of the cotton spread at the front of the machine, is delivered at the other end, where the lap is made, three or four times longer than the length spread.

There is more sand and dust flying about the picking house and in the inside of the machine than there is in any other department of a spinning factory; and the consequence is that, very frequently, the journals get heated, if the utmost care is not taken to keep them well oiled and regularly cleaned. Even with all the attention of the most careful workers, sometimes

they do get heated up to such a degree that the journals are either destroyed or very much damaged. This heating most frequently occurs with the journals of the scutchers, caused by the great speed at which they run, and many contrivances have been tried to prevent them from heating. One simple way of preventing the sand getting on to the journals is, to have the oil holes plugged up at all times, except when oiling, and a tin cover put on, sufficiently long to project over the ends of the bushes. This, to a great extent, prevents the sand getting on to the journals, although not completely.

CARDING.

The carding engine, as it is at present constructed, is one of the most important machines in the spinning factory. Indeed, if it had not, by one improvement after another, been brought so near perfection, spinning would not be so far advanced as it is. There is no doubt that, by the old eighteen and twenty-four inch cards, some very superior yarn was spun from their produce; but the quantity they put through is extremely small, compared with the large ones, and, except in mills where the highest counts are spun, these old cards cannot be kept working with any chance of success; and now few spinners who are spinning low and medium numbers continue to

use them. There are many different sizes of the carding machine, and also a variety of makes; but they are all intended to produce the same result. Before the cotton is brought to the cards, it has gone through the process of being mixed, opened up with the willow, loosened, and further opened up by the scutching machine, and then made into a lap by the spreading machine. In all these processes, the cotton is still in a confused mass, with the fibres lying in all directions, no attempt having been made to arrange the fibres in any particular manner. Now, the use of the card is to take each fibre by itself and make it straight, and then to lay them parallel with each other (if that were possible) to form a sliver or card-end. Although the carding does not make all the fibres straight and parallel to each other, it prepares them for being made so.

With the original hand cards, the worker could make the fibres straighter than the carding engine can ; because the hand cards consisted of only two boards, with a sheet of card tacked down on them, and the worker put a little cotton on one of the sheets and combed out the fibres with the other ; and this process of combing was continued until the worker saw that the fibres were all properly straightened. This hand carding was used only for the one spindle wheel, no drawing frames being used, as at present, for straightening the fibres.

About seventy years ago, the carding engines made as good carding, as regards quality, as any of the present engines, although the quantity they produced was very small; and, as the principles are the same in both, I will give a short description of them, as some things about the old cards might yet be applied, with advantage, in combination with some of the articles on the new ones.

The cylinder of the old carding engine was about three feet in diameter, and eighteen inches broad. It consisted of two cast-iron rings. In the centre of these rings, holes were bored for the axle, which is turned to fit the holes in the rings, the journals being turned at the same time, so as when the cylinder is built, it can be turned, when running, in its own journals. There are holes bored in the flanges of the cast iron rings, at suitable distances, for the small bolts that fix down the staves. After the rings are fixed upon the axle, it is ready for being what is called "built."

For some months previous to commencing the building of the cylinder, the wooden staves are all cut out of bay mahogany, about five inches broad and three inches thick, and as long as will make the breadth of the cylinder. It is requisite to have the wood well seasoned, before beginning to put it on to the cast iron rings to form the cylinder. The builder—who is, in general, a millwright—begins his operations by giving

the side of the staves that goes next to the rings a curvature corresponding to the diameter of the rings. He then planes the edges to a level suitable for making a good joint. The proper bevel can be ascertained by drawing a circle of the same diameter (on a drawing board) as the rings, and another of the same diameter as the cylinder will be when the wood is on, and then drawing radius lines from the centre to the circumference. When the staves are prepared thus far, they are ready for being bolted upon the cast iron rings. The workman takes the first stave, places it upon the cast iron rings, and marks upon it where he has to put the bolts in. After the first is bolted on, he takes the second and fits it to the first, bores the holes in it, and bolts it down; and so on with the rest, until the cylinder is finished. The heads of the bolts are sunk fully one inch below the surface of the wood, and, after all the staves are put upon the rings, these bolt holes are filled up with pieces of mahogany being glued into them. When the glue is properly dried, the cylinder is ready for being turned. At the first turning, it is only roughly done, the finishing of it being left until the carding engines are put into the factory.

The sides of the card are made of cast iron, and the upper part of them form half a circle. A flange is cast on this half circle, projecting about two inches to the inside of the card. It is upon this flange

that the screw pins are arranged, for the adjustment of the tops or flats These tops or flats are pieces of mahogany two inches and five-eighths broad and one inch and seven-eighths thick, which are dressed up with the plane, and made to suit the place in which they are to lie on the top of the card. On the sides of these tops that go next the cylinder, is fixed, by small tacks, a card sheet. The framing of the card is made similar to those at present in use, and is arranged so that all the working parts can be fitted on to the sides, such as the lickerin, the doffer, feeding rollers, wheels, &c. In these early times, both the lickerin and doffer were made in the same way as the main cylinder of the card, being covered with wood; but, for many years back, the doffer and lickerin have been made of cast iron, and on these old cards the diameter of the lickerin was seven or eight inches, and the doffer twelve or thirteen inches, and the length the same as the breadth of the main cylinder.

On one end of the axle of the main cylinder there is a pair of pulleys fourteen inches in diameter and two inches broad. One of them is fixed upon the axle, and the other is loose. They are called the driving pulleys. Behind the driving pulley, there is another pulley, with a groove, for the purpose of driving the lickerin with a band. This grooved pulley is about eighteen inches in diameter. There is also another pulley for driving the comb. On the other end is a

pinion, which gives motion to the other parts of the card. This pinion is geared into two other pinions (these are intermediate), one on each side — the one giving motion to the doffer and delivering rollers, the other giving motion to the feeding rollers. The pinion on the axle of the cylinder has twenty-four teeth, and the first wheel for leading motion to the doffer and delivering rollers has one hundred and fifty (the intermediate one is not taken into calculation), and on to the axle of this wheel there is a pinion having forty teeth gearing into the second wheel, that has fifty teeth, and this is the wheel which drives the doffer. The speed of the main cylinder being one hundred and twenty revolutions per minute, how many will the doffer make?

EXAMPLE No. 16.

```
Speed of main cylinder,          120
Number of teeth in pinion,        24
                                 ---
                                 480
                                240

Teeth in first wheel,     150)2880(19 2 speed of first wheel.
                                150

                                1380
                                1350
                                ----
                                 300
                                 300

Speed of first wheel,             19 2
Teeth in second pinion,             40
                                  ----
Teeth in second wheel,     150)7680(5 12 speed of doffer.
                                 750
                                 ---
                                 180
                                 150
                                 ---
                                 300
                                 300
```

There is another method of making this calculation; but I consider it less simple than that given. Multiply the teeth of the pinions together, also the teeth of the wheels together, then multiply the speed of the cylinder by the product of the pinions, and divide by the product of the wheels, for the speed of the doffer.

EXAMPLE No 17

```
Teeth in first pinion,  24
  ,,     second  ,,     40

                       960 product of pinions

Teeth in first wheel,  150
  ,,     second  ,,    150

                      7500
                     150
                     -----
                     22500 product of wheels
```

EXAMPLE No 18

```
        Speed of cylinder,    120
        Product of pinions,   960
                              ---
                             7200
                            1080

Product of wheels, 22500)115200(5·12 speed of doffer.
                         112500

                           27000
                           22500
                           -----
                            45000
                            45000
```

There are some intermediate wheels between the doffer wheel and the pinion that drives the delivering rollers; and, in tracing out the speed for the rollers, these intermediate wheels are not taken notice of. It is requisite to take into calculation the circumference of the doffer, as well as the number of revolutions that it makes in one minute, because the fibre of cotton thrown on to the doffer, by the main cylinder of the card, must be taken off by the comb at the same rate of speed as that at which the circumference of the doffer travels. If the fleece were taken too quickly off, it would be uneven; and the same effect would be produced by it being taken off too slowly; so that the doffer, the comb, and the delivering rollers must work in unison with each other, to make a good sliver or card end.

We have seen that the speed of the doffer is 5·12 revolutions per minute, and that the wheel with which it is driven has one hundred and fifty teeth. It is this wheel that drives the delivering rollers, which are two inches and a half in diameter, and the diameter of the doffer is twelve inches. What is the number of teeth the pinion will require to have to give the proper speed to the delivering rollers? First, find the length in inches that the doffer will give out in one minute.

EXAMPLE No 19.

Diameter of doffer, 12 inches.

```
     24
    24
   ---
  7)264(37 71 circumference of doffer.
    21
   ---
     54
     49

      50
      49
     ---
       10
        7
```

```
Circumference of doffer, 37 71
Speed of doffer,          5 12 per minute.
                        ------
                          7542
                         3771
                        18855

                       193 0752 inches of sliver per minute
```

The next thing to find is, how many revolutions the roller will require to make per minute to take up the one hundred and ninety-three inches of sliver. The diameter of the balls that are on the delivering rollers is two and a half inches.

EXAMPLE No. 20.

```
Diameter of balls, 2·5 inches.
                    22
                   ----
                    50
                   50

                 7)550(7·85 circumference of balls.
                   49
                   ---
                    60
                    56

                     40
                     35
```

EXAMPLE No. 21.

Having found the circumference of the balls, divide 193·0752 inches of card end or sliver by it, for the revolution of rollers per minute.

```
Circumference of roller balls 7·85)193·0752(24·59 revolutions per
                                   1570          [min. of rollers.
                                   ----
                                    3607
                                    3140
                                    ----
                                     4675
                                     3925

                                      7502
                                      7065
                                      ----
                                       437
```

From the foregoing calculation, the revolutions of the roller should be 24·59 per minute, and the method

of finding the proper pinion to give that speed is as follows:—Multiply the number of teeth in the doffer wheel by its number of revolutions, and divide by the revolutions the rollers make in one minute.

EXAMPLE No 22.

```
Teeth in doffer wheel,   150
Revolutions of   „       5·12 per minute.
                         ----
                          300
                         150
                        750

Revolutions of rollers, 24 59)76800(31·23 teeth in roller pinion.
                              7377

                               3030
                               2459
                               ----
                                5710
                                4918
                                ----
                                 7920
                                 7377
                                 ----
                                  543
```

The teeth in roller pinion comes out in calculation to be 31·23. As there cannot be a fraction of a tooth, the fraction must be dropped or made a full tooth; in this case it should be dropped, and the pinion selected is thirty-one teeth; because, if there is to be any difference between the speed of the rollers and that of the doffer, the rollers' should be the greatest, so that the fleece will not hang loose between the doffer and the rollers.

For many years after the invention of the cylinder "carding engine," the cotton was taken off the sheets in rowans—that is, not in a continuous fleece. The rowan was as long as the card was broad, the doffing cylinder being covered with card sheets, instead of a fillet card, as it is at present. The detaching of the cotton from the sheets on the doffer was performed by a person who stood in front of the doffer, with a hand card, ready to strip each individual sheet as it came round. It was these stripes which formed the rowans. This plan of stripping off the rowans was superseded by the introduction of a scraper, which did not perform the operation satisfactorily. Arkwright is credited with being the first to introduce a system by which a continuous rowan or card end could be made. To accomplish this, he did away with the card sheets on the doffer; there being a space between each sheet, it was not practicable to make a continuous fleece with them; and, instead of having a number of sheets, he employed only one, made about one and a half inches broad, and sufficiently long to cover the whole doffer when wound round it in a spiral form. This long sheet is now called a "fillet." The card sheets were fixed on the doffer by small tacks being driven through the leather at each side of the sheet; but the fillet required only to be fixed at each end. By this contrivance, there were no spaces left on the doffer uncovered, which enabled him to form a continuous fleece

of cotton on the doffer; but how to get this off, to make a continuous rowan (or what is now called a card end), would very likely occupy Arkwright's mind before he introduced the fillet. The mode of taking off the cotton by hand cards was familiar to Arkwright, and he would naturally think that, if these rowans could be joined together so as to make a continuous rowan, it would be a great advantage in the process of carding, and that, if he had some apparatus that would make very narrow rowans, without separating them, his object would be gained:—and this is exactly what is done by the comb.

The article that was used in the card, under consideration, for stripping the doffer of its cotton fleece, was a thin piece of steel, a little longer than the doffer, and about one inch and a quarter broad. One edge of this piece of steel was serrated and sharp like a small-toothed comb—hence its name. The comb was fitted neatly on to a piece of bay mahogany, one inch and three-quarters broad and three-quarters of an inch thick, and fixed with small screw nails, for the purpose of stiffening the thin steel comb. This piece of mahogany, with the comb, was attached to a vibrating rod, which received its motion from a small crank shaft, and this shaft was driven by a band from the grooved pulley on the axle of the main cylinder. The speed of the comb was about three hundred and fifty strokes per minute (much slower than at present), and it traversed,

each stroke, two and a half inch. Although the traverse was two and a half inches, the comb only stripped about half an inch of the fleece at each stroke. It is by these short and repeated strokes that a continuous fleece is made; and then, by contracting it and making it pass through the filler and between the rollers, it is formed into a sliver or card end.

There were sixteen pieces of wood for tops, but only thirteen were sheeted with card sheets. The one next the doffer, for the purpose of screwing the hinges of the doffer cover to, and the one next to it, had no sheets; also, the one nearest the feeding rollers was left unsheeted. The cover for the doffer was merely to protect the fillet from being hurt by anything falling upon it.

The pinion that drives the wheels on the doffer side of the card, drives, also, the wheels and pinions on the feeding side of it; and that pinion was seen to have twenty-four teeth, and that the main cylinder of the card made one hundred and twenty revolutions per minute.

There is a number of intermediate pinions on the feeding end of the card similar to the other end, but they are put there merely for the purpose of transmitting the motion from one pinion to another; and, as noticed before, have nothing to do in either increasing or diminishing the speed—therefore, they are left out in the calculation.

To find the speed of the feeding rollers, first multiply the revolutions of the cylinder by the number of teeth in the pinion on the axle of the cylinder, and divide by the number of teeth in the wheel which this pinion drives.

EXAMPLE No. 23.

```
Revolutions of cylinder,    120
Teeth in pinion on axle,     24
                            ---
                            480
                           240
                           ----
Teeth in wheel, 160)2880(18 revolutions of first wheel.
                    160

                    1280
                    1280
                    ----
```

The next calculation is to multiply the revolutions of the first wheel, which are eighteen in number, by the number of teeth in the pinion that is on its axle, which is fifteen.

EXAMPLE No 24.

```
Revolutions of first wheel,       18
Teeth in pinion on axle,          15

                                  90
                                 18
                                 ---
Teeth in second wheel, 160)270(1 68 revolutions of feeding
                           160                    [rollers.
                           ----
                           1100
                            960
                            ----
                            1400
                            1280
                            ----
                             120
```

It will be observed that there is a great difference between the speed of the feeding rollers and that of the delivering balls; but it does not follow that the carding is either too light or too heavy, because that altogether depends upon the weight of the lap, which can be made thick or thin, at the spreading machine, in accordance with the idea of the manager or carding master. For many years previous to these cards being partially superseded by the larger ones, the speed of the doffer was very much increased—some of them having a speed that gave a delivery of fleece three hundred and fifty inches long per minute, without any increase in the speed of the main cylinder.

In front of the feeding rollers there were two brackets for guiding the journals of the wooden roll that the cotton was wound upon at the spreading machine. These brackets had slits in them for receiving the iron rod that is in the centre of the wooden roll, and, as the roll unwinds the cotton, it descends in the slits. Right below the slits in which the lap roll lies, there is a roller three inches in diameter; it is made of wood, with an iron arbour through the centre of it. There are grooves made lengthwise on the circumference of this roll, for the purpose of taking a better hold of the cotton that composes the lap. The lap is supported and driven by the roll, and, of course, must go at the same speed as the feeding rollers of the card; and, to ensure that the lap will be turned by the

wooden roller, a weight is suspended at each end of the lap to press it down upon it—that is, to press the lap against the wooden roller.

As a considerable amount of short cotton and dust flies off in the carding, the main cylinder is enclosed, by having the sides and ends of the card lined with wood. At the bottom of this lining there are openings, with doors on them, for the purpose of allowing the worker to clean out the flies and dust from under the cylinder.

The feeding rollers being only one inch and an eighth in diameter, and the wooden roller by which the lap is driven being three inches, it will require to make fewer revolutions per minute. In the example given, the revolutions of the feeding rollers are 1·68 per minute. What should be the speed of the roller three inches in diameter, which is equal to twenty-four eighths of an inch?

EXAMPLE No 25.

```
Speed of feeding rollers,      1·68
Diameter          ,,              9
                               ----
Diameter of wooden roll, 24)1512(·63  speed of wooden roll.
                            144
                            ---
                              72
                              72
```

The speed of the wooden roll is ·63, and the pinion on the feeding roller has fifteen teeth. To find the

number of teeth for the wheel, multiply the speed of the feed roller by 15, and divide by ·63.

EXAMPLE No. 26.

Speed of feeding roller,	1·68
Teeth in pinion,	15
	840
	168
Speed of wooden roll,	·63)2520(40 teeth for wheel.
	252

The wheels and pinions being on the card, the speed is found in the usual way.

EXAMPLE No. 27.

Speed of feeding rollers,	1·68
Teeth in pinion,	15
	840
	1680
Teeth in wheel,	40)2520(63 speed of roller.
	240
	120
	120

How the workers did, in the management of the carding engine under consideration will now be taken notice of. When the cards were delivered by the machine maker into the factory, they were allowed to stand in the carding room for a length of time—that time being determined by the state of the wood; for, until the wood of the card is sufficiently dry, nothing

is done to it, except the putting of it in its proper place where it is to work; and this is done in the same way as I have described for the setting of other machines. The measurement is to be taken from the centres of the cylinder shaft for getting it set parallel with the shaft that is to drive it; and, for making it level, the measurement can either be taken from the axles of the feeding roller, the main cylinder, lickerin, or doffer, for all these must be parallel to each other, so, when one is set parallel to the driving shaft, all the others should be.

When the cards are properly dry, the first thing that is done to them afterwards is to put the belt on, and allow it to run for some time, having previously oiled all the journals and studs. It is at this time that the workman inspects all the running parts, to see if all is right about them; for example, that the wheels and pinions are properly in gear, for, if they are too deep or too shallow in pitch, they are very apt to be damaged. The next thing is the turning of the cylinder; for, although it was roughly turned before it was taken from the machine shop, it was not finished.

The system adopted in the factory for turning the cylinder is as follows:—A slide rest, as long as the card is broad, is fixed on the arms that project from the card sides at the end at which the feeding rollers are. The rest is made parallel with the axle of the

cylinder, and the turning tool is fitted in the bracket that slides along the rest. There is a thumbscrew behind the turning tool, for the purpose of screwing it forward towards the cylinder, as required. The first cutting is done by a tool similar to a wood-turner's gouge; but the tool that gives the finishing cut is a broad chisel or a plane iron. In finishing the cylinder, the tool merely scrapes off a little of the wood at each traverse on the slide, until it is made quite true. After this, the cylinder is ready for sheeting.

The sheeting of the card is, in general, done either by the carding-master himself or by the head sharper, as it requires to be very carefully done. The cylinder is made fast, to keep it from turning round, and the first sheet is laid on near the top of the cylinder, and the edge of the sheet furthest from the sheeter is tacked down to the surface of the cylinder. Then the other edge of the sheet is taken hold of by pincers; the legs of the pincers are looped and set apart from each other, and a leather strap is put through the loops, which reaches down to the sheeter's foot; the strap being double when it is pressed down by the sheeter's foot, the sheet is made tight, and then the other side is made fast with tacks. The pincers take hold of only three or four inches at a time, and only that length is fixed with the tacks. The pincers are shifted three or four inches for a new hold. This operation continues

until the whole sheet is put on. The others are put on in the same way, until the whole circumference of the cylinder is covered with sheets. The person who puts the sheets on, gives the cylinder a movement from him—the distance moved corresponding to the breadth of the sheet.

The lickerin and doffer are covered with fillets, and these are put on in a spiral form: one end of the fillet is fixed on the doffer, by nailing it to small pieces of wood, which have been driven into the doffer for that purpose. (When the doffers were made of wood, the fillet was tacked to any part of the edge of it.) When the end of it is made fast, one person takes hold of the fillet and keeps it tight, while another keeps turning the doffer slowly. until the fillet is all wound on, and then the other end of the fillet is also nailed to the doffer. The lickerin is covered in the same way. When the cylinder, doffer, and lickerin are finished with sheeting, they are ready for being what is called "ground."

Although card sheets are all made to a given guage, and look, to a casual observer, perfectly even and regular in the length of the teeth, yet to those employed in the carding room, and acquainted with the carding engine, the teeth are seen to be unequal in length; hence the necessity of having the long teeth ground down to the length of the shortest.

The grinder is a cylinder covered with emery. In the centre of the cylinder is an axle, on one end of

which is a band pulley for driving it. On the other end is a pinion for driving an apparatus which causes it to traverse endwise at the same time that it is revolving. The circular motion of the grinder is the reverse way from that of the card cylinder. There are two brackets that can be bolted on to the card, and these contain the bushes for the journals to run in, and are regulated with the screw pins, so as to give the pressure that the grinder should have on the teeth of the card sheets. After the grinder is adjusted, and the band for driving it put on, the card cylinder is put in motion by its own belt, and the grinding begins and continues until the card teeth are properly done. Sometimes it takes days to do this.

The covering of the grinding cylinder with emery is a job that requires much care. The emery has to be freed from all dust and other impurities before being put on. One way of putting the emery on the cylinder is, first, to cover all the surface of it with the best glue, then to keep turning it round while the emery is being poured on the top of it — continuing this until no more emery will stick to the cylinder. The cylinder is then put past to dry. Besides these grinders for the doffer and main cylinder of the carding engine, there is another for grinding the tops or flats. This machine is placed in some convenient part of the carding room, as the tops require frequent sharpening.

When the card sheets of the cylinder, doffer, lickerin, and tops are all ground and properly sharpened, the carding engine is ready for what is called "setting" —that is, the different working parts are to be adjusted as regards each other. The journals of the main cylinder run in bushes that are fixed, and cannot be shifted either way; therefore, the lickerin must be set to suit the main cylinder, also the doffer; they are both set as close to the main cylinder as they can be without touching. The feeding rollers are set close to the lickerin, parallel to it, and on the same level. If the feeding rollers are not placed on the same level as the lickerin, the feeding of the cotton will not be done satisfactorily.

On each end of the tops, on the same side as the card sheets are on, there is a piece of plate iron to keep the wood of the tops from being worn by the heads of the pins by which the tops are adjusted. The person who sets the tops in their proper position has a small screw-key for turning the set pins (each top has four pins, two at each end); and the pins that support the edge of the tops next the feeding rollers are set a little higher than the other two, for the purpose of giving the sheet a slight incline, so that the cotton will be better thrown on to the teeth of the top sheet, than it would be if the tops were set with both edges at an equal distance from the main cylinder. The other edge of the top is set as close to

the cylinder as can be, so as not to have the teeth touching each other. The comb for taking the cotton off the doffer is made to vibrate in front of it, and, as the comb makes a segment of a circle—the reverse of the circle made by the doffer—it is set so that the teeth of the comb will strike the cotton at that part of the circumference of the doffer that is nearest the comb; at the same time, the comb must not touch the fillet teeth.

In these old-fashioned cards, a regular system of cleaning the tops was carried on all day, by a person who went from one card to another, lifting the tops one by one, and stripping them of the cotton that was adhering to them at the time. This person was named "The Topper," and had charge of twelve or fourteen cards. Suppose the twelve cards were all in one row, the topper began at one end of the row and stripped three of the tops in the first card; then passed to the second card, and stripped three of the tops in it; then to the third; and so on to the end of the whole row of cards—stripping three of the tops in each. Then the topper goes back to the other end of the row, and repeats the former operation, but with the three tops coming in rotation to those that were stripped at first. Besides the topper, there was a worker for brushing out and sharpening the card sheets. This sharpening of the card was done by a piece of flat wood, covered on one side with emery.

The worker employed was usually a full-grown person, and was called "The Sharper." Other two workers completed the number of hands employed at the cards; and these were children—one for the front of the card, and another for the back. The one at the front put the laps in and attended to them; the one at the back saw that the card ends went properly into the cans, and, at short intervals, slightly pressed down the card ends into the cans, when they accumulated at the mouth of the can. It was the practice then, to deliver the produce of two or three cards into one can. When three cards' produce was put in one can, the can was placed opposite the centre card, in the middle, at the front, and the card end from the one on each side was led to the delivering rollers of the centre card, and all the three "slivers" were compressed into one and put into the can. If, by any mistake or carelessness, one of the card ends is a-wanting, while the other two are going on, the worker has to draw out of the can the length that has been put in without the third end. Of course, this part of the card ends is made into waste, which is sent back to the picking house to be put through again.

At the time when these small cards were in use, it was the common practice to have "double carding" —that is, when one set of cards had put through the cotton, and formed it into card ends or "slivers," twelve, fourteen, or sixteen of the cans, with the card

slivers in them, were taken to a machine called the "lapping machine," and the end of each sliver was collected, and entered between the rollers of the lapping machine, to form a new lap for the second set of carding engines. The mode of making the lap for the finishing card was, first to wind, on the lap roller, all the sixteen card ends, until the required diameter of the lap was made; then to take this one out and put in another roller, having the lap that was made first, placed on the two bushes that were fixed in brackets right above the calender rollers of the lapping machine. The end of the first lap is again put through between the calender rollers, along with the sixteen ends from the cans, and a second lap is made which contains card ends equal to thirty-two. This second lap is the one that is put into the finishing card, for the purpose of being carded over again, and again reduced to a card end or "sliver," ready for being taken to the drawing frame.

This amalgamation of the produce of thirty-two breaker cards had a very beneficial effect upon the yarn that was spun from the cotton prepared in this manner; for any inequality that happened in one card was rendered almost null, by this intermixing at the finishing card. The setting and working of the finishing card were the same as those of the breaker; also the mode of calculation was the same. But the card sheets were finer than those that were used in the breaker card.

The carding engine, which we have been describing in the foregoing pages, looks a tiny little thing, when compared to the carding engines of the present day; but, however much the one is superior to the other in regard to the quantity put through in a given time, the quality of the work done is not superior. The principles of carding remain the same, whatever may be the machine in which it is performed; and there is no doubt but that a point can be reached at which it would be undesirable to enlarge them further; but what that point is, it would be difficult to determine at present; but it is obvious that the surface of the carding cylinder, after it has attained that speed at which the centrifugal force is too great to retain the fibres of the cotton, it would be useless to go beyond that speed, and that it is an easy matter to give the cylinder in the common carding engine that velocity. However, it is not so evident when the proper breadth is reached.

The first enlargement from the eighteen-inch carding engine was to the twenty-four inch one, the diameter of the main cylinder being in both thirty-six inches. Then an attempt, attended by a certain amount of success, was made to improve the system of "topping" by having the "flats" cleaned by a self-acting apparatus. The tops or flats revolved on an endless chain, and, when the tops came round with their sheets, turned uppermost to a certain point, they were cleaned

by a rotatory brush, and the stuff that came off the tops fell into a box that was fitted up at the carding engine for the purpose of collecting it.

After this, were introduced carding engines, which had two large carding cylinders—each thirty-six inches in diameter, and twenty-four inches broad, besides the lickerin and doffer. There were also, about this time, some carding engines made with cylinders forty-eight inches in diameter, and forty-eight inches broad; so that breadth of wire was exactly double that of the twenty-four inch cards. Suppose the carding was the same weight in this engine as it was done in the eighteen-inch ones, the card end for a given length would be equal to nearly three of the eighteen-inch ones, and there would be no excuse for delivering the produce of more cards than one into the same can. A number of other cards, about the same size as the forty-eight inch one, with different modifications in the way they were fitted up, as regards cleaners and tops, has been tried and partly laid aside. There is a number of carding engines working in different factories much larger than those of which I have taken notice; but the only difference is their size.

The large carding engines for the low numbers are, in general, made with cylinders both large in diameter and broad, for the purpose of putting through a large quantity; and they are mounted with a number of

small rollers placed round the top half of the main cylinder, and in the same relation to the main cylinder as were the flats in the old carding engine.

I will now give a short description of what, at the present day, is considered the best carding engine for yarns above No. 100s. It has none of the circular cleaners, but, instead of them, the flats of the old description are employed. The upper half of the card is nearly covered with them, the number depending upon the diameter of the main cylinder; for these cards are not made all the same size. However, both the small and the large ones are fitted up on the same plan. The feeding rollers, the main cylinder, and the doffer are of the same kind as the old card that has already been described; also, the tops or flats; but the improvements lie in the apparatus for stripping the flats, which is called "topping;" the apparatus for doing the work is called the "self-acting topper." The mechanism of the topper can be arranged so that it will take the flats in rotation, or it can take one and miss two, or take each alternate one, and in any other way that may be thought advisable. It is the most complete system of topping that has been brought out, and works well.

The can for receiving the card end is placed in front of the card at one side, and is made to revolve at a speed corresponding to the speed of the card end. The workers, that are requisite for attending to these

self-acting cards, are few in number, compared with those required by the old system.

The following list contains some of the numbers and sizes of card sheets, or, what is generally called "card clothing." The fineness of the sheet is determined by the number of wires in a given space, the greater the quantity in the given space the finer are the wires. To ascertain the comparative fineness of the card sheets (these are the sheets that are put on to cover the circumference of the main cylinder), count the number of teeth in one row across the sheet, and multiply this by the number of teeth that are in one row in the length of it. This will give the whole teeth in one sheet, and this divided by the number of square inches in the sheet, will give the number of teeth in one inch. Perhaps an easier method is to measure off exactly one square inch, and count the teeth within the space. There is no absolute rule, that can be given for the different kinds of yarn that are spun, as to what fineness the sheets should be in comparison to the yarn; that will depend upon the material that is to be carded, and the opinion of the manager or carding master. But it is the general custom to use the coarsest counts for lickerins, or any other parts that come first into contact with the fibre of the material that is being carded. Tow, and wool, require a sheet much coarser than what is requisite for cotton. The prices that are given in the list are merely nominal.

LIST OF CARD SHEETS.

SHEETS, No	70	80	90	100	110	120	130	140
36 × 4 .	3/1	3/3	3/5	3/7	3/9	3/10	4/1	4/4
40 × 4 ..	3/5	3/7	3/9	3/11	4/1	4/4	4/7	4/9
48 × 4 .	4/3	4/5	4/7	4/9	4/11	5/2	5/5	5/8
FILLETS								
1 in.	3	$3\frac{1}{8}$	$3\frac{1}{4}$	$3\frac{3}{8}$	$3\frac{1}{2}$	$3\frac{5}{8}$	$3\frac{3}{4}$	4
$1\frac{1}{2}$ in.	4	$4\frac{1}{4}$	$4\frac{1}{2}$	$4\frac{3}{4}$	5	$5\frac{1}{4}$	$5\frac{1}{2}$	$5\frac{3}{4}$
2 in	$5\frac{1}{2}$	$5\frac{3}{4}$	6	$6\frac{1}{4}$	$6\frac{1}{2}$	$6\frac{3}{4}$	7	$7\frac{1}{4}$
TOPS								
36 × $1\frac{1}{8}$ ...	1/1	1/2	1/3	1/4	1/5	1/6	1/7	1/8
36 × $1\frac{1}{2}$ ...	1/6	1/7	1/8	1/9	1/10	1/11	2/0	2/1
36 × $1\frac{3}{4}$	1/9$\frac{1}{2}$	1/10$\frac{1}{2}$	1/11$\frac{1}{2}$	2/0$\frac{1}{2}$	2/1$\frac{1}{2}$	2/2$\frac{1}{2}$	2/3$\frac{1}{2}$	2/4$\frac{1}{2}$
40 × $1\frac{1}{8}$	1/3	1/4	1/5	1/6	1/7	1/8	1/9	1/10
40 × $1\frac{1}{2}$.	1/9	1/10	1/11	2/0	2/1	2/2	2/3	2/4
40 × $1\frac{3}{4}$ ...	2/0	2/1	2/2	2/3	2/4	2/5$\frac{1}{2}$	2/7	2/8$\frac{1}{2}$

DRAWING FRAME.

How this machine was named the "drawing frame" I cannot exactly say, for a number of the other machines connected with spinning have an amount of draught or drawing. The spreading machine gives out a greater length than it receives in, although the same weight. The carding engine draws out a much longer length than it receives; also, the slubbing and fly frames have a considerable amount of drawing. The spinning machines, too, the last in the process, have also a draught; but it may have received its name from the frequency of the doubling and drawing that this machine gives to the material. It has been called by some "the doubling machine," although other machines are called by that name.

The use of the drawing frame is to reduce the card ends to a certain thickness, by drawing out a given length many times longer; and, by this drawing, the fibres of the cotton are made straight and parallel to each other. Although the carding draws out the fibres of the cotton, and makes them straight to a certain degree, it does not do it sufficiently.

There is a story told that Arkwright got his idea of the drawing frame (which is his invention), by observing a bar of red hot iron being passed through between a pair of rollers. If this is true, the hint was a very small one, for there is little or no analogy

between a pair of rollers for elongating iron, and two or three pairs that are used for the drawing of cotton. It is more likely that the idea would be got in this way: When Arkwright lived, very many houses were thatched; and the person who was employed in thatching carried up a bundle of straw, which he put before him on the rigging of the house, then pulled out a small bunch of the straw with his right hand, and, taking hold of the other end of the bunch with his left, he pulled the straw into two parcels, and laid them parallel to each other. This operation was repeated until the thatcher got all the straws made straight and parallel. It is an identical operation, that the cotton broker performs when he tries the quality of cotton. This was a far more likely thing to suggest the idea of drawing out the fibres of cotton, than the mere squeezing or rolling out of iron rods.

Before machinery was introduced for drawing, the person who spun the yarn did the drawing process by the finger and thumb, at the same time as the yarn was being spun. I will now describe the machine for performing this very simple operation. There have been many modifications of the drawing frame, but the principles in all are the same. One machine consists of two cast iron rails called the "roller beams." Upon these rails are fixed the stands for supporting the rollers. The length of the beams depends upon the number of stands, or heads, that are

to be placed upon them; in some there are six pairs, in others eight or ten pairs. The two beams are placed about six inches apart, and, on the front beam, there are brackets for supporting the delivering balls, or rollers. There is a small shaft at the bottom of the machine, which extends from the one end of the machine to the other. This is the main shaft of the drawing frame, on the end of which are the driving pulleys. For each set of rollers there is a pulley on the main shaft for driving them—if there are ten sets of rollers there will be ten pulleys. What is meant by a set of rollers is the number that is contained in one head—four pair of drawing rollers, and one pair for the delivery of the sliver into the can; these are sometimes called the delivering balls. Each set has a separate system of driving gear, so that any one set can be stopped or put [illegible] on independently of the others, by shifting the [illegible] belt from the one pulley to the other, as the [illegible] may be, the main shaft of the frame being [illegible] in motion during the working hours of the factory.

It is requisite to have a certain amount of pressure put upon the top rollers of the drawing frame, not only for the purpose of compressing the cotton, but also for taking a firm hold of the sliver, so that the fibres of the cotton may be separated from each other or drawn out. The back pair of rollers are going at a slower speed than the pair next them, and if the back

pair had not a sufficient hold of the cotton, it would be pulled through without the fibres being separated; and to give this pressure to the top rollers different plans have been adopted.

One way, is just to hang pieces of cast iron to the ends of the top roller by a brass rod hooked at both ends. This plan does very well when there is room to get them applied, as it is more evenly in its action than the plan with the springs. But, when the cotton is heavy to draw, lever power is taken advantage of; instead of hanging the weight to the under hook of the brass rod, a lever is made to rest in it, and the weight is hung upon the lever, so that it can be shifted on it, to give whatever pressure may be required for the different kinds of cotton. An objection has been made to the dead weights, because they take up too much room in the machine, and give a very large amount of extra weight upon the floor. There are also complaints made about the lever plan for putting on the pressure upon the drawing frame rollers, as, when there is any inequality in the sliver, it causes the weights on the levers to jerk up and down, making the process of drawing the fibres of the cotton unsatisfactory; and, to avoid the evils of these two plans, springs have been adopted by some. The springs, when properly applied, have the advantage of a more evenly pressure; also, the nature of the spring puts on a greater pressure, as the sliver

gets thicker, at the very time that a greater strain should be put on, so as to have a firmer hold of the cotton. When the springs are being set, they are adjusted to give the pressure required by a screw and nut.

The under rollers of the drawing frame are made one and three-eighths of an inch in diameter, and are fluted longitudinally. But, in some of the old make of machines, the rollers are only one and a quarter-inch; and some are even made less than this, being only one and one-eighth of an inch in diameter. The top rollers are not made parallel, but have bosses which are covered with leather, the part covered with leather being the part of the roller that presses upon the cotton. The joints of the leather have to be very neatly made, for, if any roughness were left at the joinings, the cotton would be caught by it, and cause what is technically called "lapping," that is, the sliver coiling round the roller. As the rollers have always to be kept clean, both the top and bottom ones have pieces of wood covered with woollen cloth for that purpose. These are called "cleaners;" and, when the machine is in operation, they are kept in contact with the rollers; the worker removing the dust and stuff that collects upon the cleaners, from time to time, as it is required.

There is another drawing frame at present in use, which is very well liked by cotton spinners. It is in many respects the same as the one described, the

principal or only difference being in the arrangement of the rollers. There is only one roller beam on which all the stands are placed, and in these stands are four pairs of rollers. The draught that is to be given to the sliver is divided between the back roller and the front one. If the whole draught in the first head be seven inches, it may be divided as follows:—

Between the back roller and third, - -	$1\frac{3}{4}$	inches.
Between the third and second, - - -	$2\frac{1}{2}$	,,
Between the second and front, - - -	$2\frac{3}{4}$	,,
Draught in all, - - - - - - - - -	7	,,

The draught may be increased or diminished to suit the kind of cotton that is being used at the time, and the quality of yarn that is intended to be spun. The draught given at the first head of the drawing frame, will, to a certain extent, depend upon the weight of the card ends, and the number of these ends that are to be put through the rollers at the same instant. If the sliver at the first head be reduced to the size that is to be delivered at the last head of the drawing frame, and, if six cans from the first head be put up at the second, third, fourth and last head, then the draught in all the drawing frame heads (except the first) will have to be six inches at each head; but there is no necessity for having the sliver reduced at the first head to the size which is required to go to the slubbing frame; if it is desirable,

each head in the frame may have the same draught, and have the sliver reduced in size at each successive head; it is altogether a matter of choice with the manager.

It is very desirable that the size of the sliver should be tested at the drawing frame. Some head should be fixed upon by the manager or carding master, from which the sliver is taken for that purpose, and to this head, an index is attached. It is preferable to have the index on the last head of the frame, as it is from this head that the sliver is taken direct to the slubbing frame; or it may be that there is no slubbing required, and in that case, the drawing frame slivers are taken to the finishing fly frame, and made into rove, ready for the spinning machine.

The index is an arrangement of clockwork contained in a circular case, and the wheels are so arranged that they indicate the number of yards of sliver that have been delivered into the can. Motion is communicated to the index by the delivering balls, a worm being fixed on the arbour of one of them, and this worm gears into a small pinion that is attached to the index.

When the superintendent is going to try the weight of the sliver, he takes a tin can (which is kept for the purpose) to the drawing head, which has been fitted up to receive the index, and puts it under the delivering rollers. He then attaches the index, and runs the length of sliver that is required into the can. That

length may be made any number of yards the superintendent thinks most suitable for the kind of machine that is to come next in the process, which may be the slubbing frame or fly frame; but, whatever may be the length that he fixes upon, it should be one of the divisions of the spyndle, or a quantity, the yards of which, when multiplied by a common number, will make up the number of yards contained in a spyndle, or one of the divisions of a spyndle. In the spyndle for cotton yarn there are a hundred and twenty yards in one skein, and seven skeins in one hank, and eighteen hanks in one spyndle; in all, fifteen thousand one hundred and twenty yards. In the spyndle for linen yarn there are three hundred yards in one cut, and two cuts in one heer, and twelve heers in one hisp, and two hisps in one spyndle; making in all fourteen thousand four hundred yards. It will be evident that, by adopting any number which will correspond to one of these lengths, it will be much easier to calculate the draughts required to make the sliver into the slub or rove that is wanted.

Suppose the number of yards fixed upon be eight hundred and forty, which is the measure of one hank, and this one hank weighs sixteen ounces or two hundred and fifty-six drachms, and, as it is the number of hanks contained in one pound avoirdupois that constitutes the size of both rove and yarn, the sliver, if twisted without any further drawing or

elongation, would be called one-hank roving; and suppose that, at the slubbing frame, it receives eight inches of a draught, it would then be number eights or eight-hank roving. If the eight hundred and forty yards of sliver weigh thirty-two ounces or two pounds, that would only be four hundred and twenty yards to the pound weight, or half-hank rove; and, if it were put through the same slubbing frame as the sixteen ounce sliver, then the roving would be four hanks or number fours. But, if the draught at the slubbing frame were only four inches, to the one of sliver, instead of eight, the slub or roving would be number twos, because there are only two hanks in the pound. For every inch of draught more, when the sliver is one pound weight and eight hundred and forty yards long, the size of the roving is increased one number higher. If the sliver that weighed one pound had got ten inches instead of eight of a draught, the roving would have been number tens; or if the draught had been only six to one, then the size would be number sixes. Suppose again that the sliver weighs four pounds, the length of it for one pound will be only two hundred and ten yards; which is one-fourth of a hank, and if twisted, without any drawing, it would be called quarter-hank rove; and if this were drawn one inch, it would be half-hank rove.

I have endeavoured to make the foregoing remarks regarding the size of the sliver as plain as possible,

because many workmen, whose duty it is to look after the sizes, do not understand the theory; but by practice know very well how to change from one size to another.

It will be seen, from what is stated, that by adopting for a measure the eight hundred and forty yards, it will be an easy matter for the carding master to make out a small table for his guidance, when changing the pinions, to bring the sliver to the proper size. By having such a table it will save time that would otherwise be spent in making the calculations, and enable the carding master to try the size of the sliver more frequently, than if he were obliged to figure it out every time.

To ascertain the draught that is given to the card sliver at the drawing frame, it is requisite to find out the speed of the different rollers. The whole draught in any single head must be between the back pair of rollers and the front pair, whatever the number of rollers that may be in the head. As already stated, the draught will depend upon the kind of cotton, and the yarn that is to be spun from it, and also upon the idea of the superintendent. If the whole draught at one head be eight inches to one, then the speed of the front rollers will be as eight to one of the back ones—that is the speed of their circumferences; for, if the front roller be larger in diameter than the back one, then the revolutions per minute will not be in that proportion, as the front roller will require to make

fewer turns per minute than eight for one of the back roller. At pages 119, 120, 125, 126, 127 and 128, it is shown how the speeds are found, and the different speeds in the drawing frame can be traced out in the same manner; beginning with the driving shaft in the carding room that gives motion to the machine, and following out all the different moving parts, such as pulleys, wheels, and pinions; not omitting to take into the calculation the diameter of the rollers. Suppose the back and front rollers are the same in diameter, and the speed of the front roller three hundred and forty revolutions per minute, (which is a very good speed for a roller one and a quarter inch in diameter), and the back one making forty-five revolutions: if the revolutions of the front roller be divided by the revolutions of the back one, the answer will be the draught that the sliver receives; which from the example, will be seen to be rather more than seven inches and a half.

EXAMPLE No. 28.

```
Speed of back roller,   45)340(7 555  draught.
                           315
                           ---
                           250
                           225
                           ---
                            250
                            225
                            ---
                             250
                             225
                             ---
                              25
                              --
                              45
```

The setting of the rollers to suit the staple of the cotton is a part of the carding master's work, which requires both carefulness and consideration. He has first to ascertain the length of the fibres, that is, of the longest fibres that are in the lot of cotton being put through; because it will not do to take an average length of the lot, there being always a quantity of short fibres mixed up with the long in any kind of cotton. When the longest of the fibres have been measured, he shifts the stands of the rollers so that the distance between each pair, where the cotton is drawn, will be from one-sixteenth to three-sixteenths of an inch greater than the length of the fibre. It would spoil the cotton to have the rollers set too close, because the long fibres would be torn asunder; neither will it do to have them set at too great a distance; and, although we have given a data for setting the roller stands, a great deal must be left to the judgment of the carding master, for it would be vain to attempt to give a fixed rule for all the different kinds of cotton that are spun.

The "balls" or rollers that deliver the slivers into the drawing frame can, is larger in diameter than are the common drawing rollers, consequently the number of revolutions made by them are less; but the space that their circumference passes through in a minute must be the same as the space passed through by the circumference of the front rollers, as the sliver requires

to be taken up by the delivering balls, as fast as it is put out by the front rollers.

The cans that receive the sliver at the carding engines are much larger in diameter than those used for receiving it at the drawing frame, and, to save the floor space at the drawing frame, only three or four card ends are put up at the first head; and these ends are delivered, when drawn, into smaller cans; and six or eight of them are put up at the second head, and an equal number at the third and fourth head; and, if it is requisite for the quality of the yarn that is to be spun, to have a greater amount of doubling and drawing than is given with the four heads, then a frame with six heads is used, and the cans are taken from the fourth to the fifth and sixth head, which gives a great increase to the doubling.

In factories, in which very fine numbers are spun, the long staple sea island cotton is used, and it requires more doubling and drawing than the other kinds that are spun into the lower counts. This extra drawing and doubling is given principally for the purpose of getting all the fibres of the cotton laid parallel; but it is now common for the spinners of these fine numbers to have, besides the drawing frame, a machine known by the name of "combing machine." The use of the combing machine is, as the name implies, to comb the cotton. One of the combing machines is very similar in its construction to the drawing frame.

The combs, which are made of steel pins about the thickness of a fine sewing needle, are so arranged between two pairs of rollers that, when the cotton is being passed from the one pair to the other, it is drawn through between the teeth of the comb, or combs, for there is a series of them, the one following the other in rotation. As one comb comes into action, one of those that have been in action, drops out; by this means a new grip of the cotton is being taken at exceedingly short intervals, which causes the fibres of the cotton to be laid parallel. Another combing machine, more commonly used in cotton spinning than the one to which I have alluded, is of a very different make, and is, by some, considered better suited for superior yarns, as it takes out almost all the short cotton, leaving nothing but the long fibres to be made into rove. Of course the greater the quantity of short cotton that is taken out, the higher is the price of the yarn that is spun from the long staple, but the yarn is proportionately better.

In factories, in which worsted yarns were spun, the combing of sheep's wool was done by machinery, long before it was introduced into the cotton spinning mills.

The drawing frames, and the combing machines, should be set down in the carding room, in a place as convenient to the carding engines and slubbing frames as possible; as there is a constant carrying of cans to and from these machines, the shorter the distance is

the better. In fitting up the drawing frame, the workman levels it from its main shaft, and keeps the main shaft of the machine in a parallel line with the shaft that gives motion to it. He also looks to see that all the wheels are properly pitched, and the small pulleys, for driving the different heads, can be set in their proper position by taking a small straight edge and applying it to the sides of the pulleys. If the two pulleys are not fairly opposite each other, the straight edge will not touch both edges of each pulley, and, when that is the case, the workman shifts the pulley that is on the machine shaft until it is right opposite the one on the drawing frame head, and fixes it there. The rollers are next shifted to the position required for the staple of the cotton that is to be put through the machine. Of course, whatever the distance between the rollers, they must be all set parallel the one with the other, and be perfectly level.

When the speeds have been calculated, and the proper pinions put on, and all the other parts of the machine put right, cleaned, and oiled, it is ready for the card ends to be put on. It is an easy matter for a worker to learn how to keep a drawing frame; yet it does not admit of any carelessness in the person who attends to it, for, by allowing any of the slivers at the back of the head to be a-wanting, a defect in the rove would be caused. Some machines have got an apparatus for stopping the head when one of the slivers runs

done, or is not going through with the others. If eight is the number of ends that are to go through, and any one of the eight is a-wanting, the head is instantly stopped, and remains standing until the worker replaces the end. The mechanism of this apparatus is similar to what is employed for stopping the warping machine when a thread breaks. All drawing frames should have the stopping gear applied to them, as it saves the time of the worker, and prevents what is technically termed "singles."

What the worker has got to do is, to remove the cans when full, and put empty ones in their places, join the card ends, and keep the rollers and the other parts of the machine clean.

CHAPTER V

SPINNING.

THE SLUBBING OR ROVING FRAME.

It is at this machine that the fibres of the material are drawn out, and receive at the same time a certain amount of twist; and with this machine spinning, strictly speaking, begins; for, although the material has passed through different machines, and has been elongated, there has been no attempt made to give it any twist to form it into a thread; and it is at the slubbing frame that it first receives twist.

After the drawing frame has done its work on the card ends, by making them into "slivers" fit to be taken to the next machine in the process, the cans with the sliver in them are removed, and placed at the back of the slubbing frame. In general, there is only one can for each spindle in the slubbing frame, but this is not always the case, for some spinners make another doubling at this machine, by placing

two cans at the back of the frame for each spindle that is in it; and, if the doubling of the card ends at the drawing frame has been brought up to forty-five thousand—which is sometimes the case—this increases it to ninety thousand; in other words, one single thread of slub, or rove, has got ninety thousand card ends to produce it.

Since the commencement of cotton spinning, many different kinds of machines for making slub have been invented, and worked for a time, shorter or longer, in proportion to the space of time, that intervened between the one invention and the next that followed. At the present time, almost all these machines (if not all) have been superseded, by the machine known in the trade by the name "fly frame;" therefore, no notice will be taken at present of any of the other machines, but a short description of them will be given in another place.

When the fly frame is used as a slubbing machine, it is made with a larger pitch for the spindles, than what is required for an intermediate, or finishing fly frame. But the construction of the principal parts of the machines are the same in all. The frames with the largest spindles and flyers are those that are used for making the slub, and those with the smallest spindles and flyers are employed for making the rove which goes direct to the spinning machine. In factories where very high numbers are spun, there may

be three or four different sizes of fly frames. Those between the largest and smallest machines are called the "intermediate frames," because they are used for reducing the rove in its grist, between the slubbing frame and the finishing fly frame. The rove that is made by the finishing fly frame, is reduced to the size (or what is termed hank roving) that is requisite for the yarn that is to be spun from it.

The reason for making the fly frames with different sizes of spindles and flyers, is this: any of the fly frames could make slub, but if it were done in one of the small machines, the bobbins would hold too little, and, if the rove were made in one of the machines with a large pitch, the bobbins would be too heavy and large for the spinning machine; hence the cause and necessity of making each fly frame with a different pitch. In factories where there is nothing but low numbers spun, only one size of fly frame is used, which makes the sliver, as it comes from the drawing frame, into rove fit for the spinning machine.

From what I have already stated, it will be seen that the use of the slubbing frame is to bring down the sliver, which comes from the drawing frame, a stage farther, to the required fineness. If the cohesive power, in the cotton, were sufficient to hold the fibres of it together, until the sliver is reduced to the standard of fineness wanted, there would be no need for twisting the sliver; but, as it has not got this cohesive

power, a certain amount of twist is given to it at the slubbing frame, for the purpose of holding the fibres together until it is reduced to the proper fineness. The exact quantity of turns of the spindle that should be given to one inch of slub or rove, depends upon the kind of cotton that is being used. The number of the revolutions that the spindle makes in the time that the front roller takes to deliver one inch of slub or rove, is called the twist that is put upon the rove. The coarse slub or rove requires very little twist, but the finer it is made, it requires the more. There are several rules which might be given for calculating the twist for the different sizes of rove, but, the one I have taken for making out the following table, I consider best. The rule is this: Find the square root of the size of rove wanted, and multiply it by a fixed number. The number fixed upon, may be greater or less, according to the number of twists per inch that is requisite for a given size of rove. The number taken for making out the table is one, decimal three. The square root of the size is confined to three decimal figures; also the fractions of the twist per inch is kept at three figures, being sufficiently near the truth for the purpose of changing the pinions. Suppose the rove to be ten-hank rove.

EXAMPLE No. 1.

The square root of 10· is	3·162	
	1·3	
	9486	
	3162	
	4 110·6	twist per inch.

The figure to the right hand being left out, the twist for No. 10^s is 4·110 per inch, that is, four turns, and fully one-tenth of a turn of the spindle, for one inch of rove. Let us take another example, where the fractions are not so small; say No. 25-hank roving.

EXAMPLE No. 2

Square root of 25 is	5·000	
	1·3	
	15000	
	5000	
	6·5000	number of twists per inch.

It will be seen that twenty-five hank roving, by this rule, requires six and a half twists per inch; that is, the spindle has made six and a half turns in the time the rollers produced one inch. The use of the table is to show, without the necessity of calculation, the number of twists per inch for slub or roving, from a quarter-hank up to sixty-four hanks. The carding master, or the person who has charge of changing the pinions for the purpose of altering the twist, finds out, in practice, a pinion that will give an exact number

of twists per inch, and he adopts the number of teeth in that pinion as one of the terms; and the twist per inch which that pinion gives for another; and, by simple proportion, finds out the pinion required for any other number of twists per inch. The spindles in the slubbing or fly frame are kept always running at a uniform speed, that is, the speed of the spindles are not altered when changing the twist upon the slub or rove; so that when a change is made to give, to the slub or rove, more or less twist, it really alters the production of the machine. When more twist is wanted, the speed of the rollers is reduced by the changing of one pinion for another, but no alteration is made in the revolutions of the spindles; therefore, the quantity produced is less, and if less twist is required on a given length, the speed of the rollers is increased, and a greater quantity of slub or rove is produced. It may be asked, "Why not increase the speed of the spindles instead of reducing the speed of the rollers, and keep up the production of the machine by the rollers giving out the same length, although not the same weight?" Well, the reason is, that all the machines with spindles that are employed in a spinning factory (and the slubbing frame is one of them) are driven up t the highest speed that it is possible to work them at with profit to the proprietor; and that speed is only restricted by the spindles, for, if the spindles could, with safety, be driven more

quickly, the other parts of the machine could be increased in speed without doing any harm. When the spindles are driven beyond a certain number of revolutions per minute, they vibrate to such an extent, that it is not profitable to work them at the great speed; and any contrivance which has been introduced, which mitigated the vibrations of the spindles, has led to an increase of the speed of the machines, and, consequently, to a larger production.

TWIST TABLE FOR HANK ROVING.

No.	Sq. Root.	Twist per Inch.	No.	Sq. Root.	Twist per Inch.
$\frac{1}{4}$	·158	·195	$2\frac{3}{4}$	1·658	2·155
$\frac{3}{8}$	·193	·250	3	1·732	2·251
$\frac{1}{2}$	·223	·289	$3\frac{1}{4}$	1·802	2·342
$\frac{5}{8}$	·250	·325	$3\frac{1}{2}$	1·870	2·431
$\frac{3}{4}$	·273	·354	$3\frac{3}{4}$	1·936	2·516
$\frac{7}{8}$	·295	·383	4	2·000	2·600
1	1·000	1·300	$4\frac{1}{4}$	2·061	2·676
$1\frac{1}{8}$	1·067	1·387	$4\frac{1}{2}$	2·121	2·757
$1\frac{1}{4}$	1·110	1·443	$4\frac{3}{4}$	2·176	2·828
$1\frac{3}{8}$	1·174	1·526	5	2·236	2·906
$1\frac{1}{2}$	1·224	1·591	$5\frac{1}{4}$	2·291	2·978
$1\frac{5}{8}$	1·276	1·658	$5\frac{1}{2}$	2·345	3·048
$1\frac{3}{4}$	1·322	1·718	$5\frac{3}{4}$	2·397	3·116
$1\frac{7}{8}$	1·371	1·752	6	2·449	3·183
2	1·414	1·838	$6\frac{1}{4}$	2·500	3·250
$2\frac{1}{8}$	1·459	1·896	$6\frac{1}{2}$	2·549	3·313
$2\frac{1}{4}$	1·500	1·950	$6\frac{3}{4}$	2·598	3·377
$2\frac{1}{2}$	1·581	2·055	7	2·645	3·428

TWIST TABLE—Continued.

No.	Sq. Root.	Twist per Inch.	No.	Sq. Root.	Twist per Inch.
7½	2·738	3·559	34	5·830	7·579
8	2·828	3·678	35	5·916	7·690
8½	2·915	3·789	36	6·000	7·800
9	3·000	3·900	37	6·082	7·906
9½	3·082	4·006	38	6·164	8·013
10	3·162	4·110	39	6·244	8·117
10½	3·240	4·212	40	6·324	8·221
11	3·316	4·312	41	6·403	8·323
11½	3·391	4·408	42	6·480	8·424
12	3·464	4·503	43	6·557	8·524
12½	3·535	4·595	44	6·633	8·622
13	3·605	4·686	45	6·708	8·720
14	3·741	4·863	46	6·782	8·816
15	3·872	5·033	47	6·855	8·911
16	4·000	5·200	48	6·928	9·006
17	4·123	5·359	49	7·000	9·100
18	4·242	5·514	50	7·071	9·191
19	4·358	5·665	51	7·141	9·283
20	4·472	5·813	52	7·211	9·374
21	4·582	5·956	53	7·280	9·464
22	4·690	6·097	54	7·348	9·552
23	4·795	6·233	55	7·416	9·640
24	4·898	6·367	56	7·483	9·727
25	5·000	6·500	57	7·549	9·813
26	5·099	6·628	58	7·615	9·899
27	5·196	6·754	59	7·681	9·985
28	5·291	6·878	60	7·745	10·068
29	5·385	7·000	61	7·810	10·153
30	5·477	7·120	62	7·874	10·236
31	5·567	7·237	63	7·937	10·318
32	5·656	7·352	64	8·000	10·400
33	5·744	7·467			

FLY FRAME.

This machine, known by the name "Fly Frame," is frequently called the "spindle and fly frame." When it was first brought into use, it was only employed for making rove—the slub being made by another machine—and the rove was made by it ready to be taken direct to the mule or throstle. The fly frame is made with a certain number of spindles, that number being regulated by the length of the machine; and the spindles are set at an equal distance from each other. On the lower end of each spindle is fixed a small bevel pinion, by which they are driven, the pinion being geared with bevel wheels that are hung upon a shaft that extends from the one end of the frame to the other. This shaft, which drives the spindles, runs at a uniform speed, consequently, the spindles are kept uniform also, which is requisite for the purpose of keeping the twist upon the rove regular. But it is very different with the shaft that drives the bobbins. The motion of it requires to be altered for every layer of rove that is put upon the bobbin.

The different motions connected with the fly frame were the inventions of different individuals, and a mechanism to accomplish the varying speed of the bobbin was a puzzle, for many years, to the machine makers and spinners. The rollers deliver the rove at a uniform rate, and the spindles give it the proper

amount of twist; but, how to get it wound upon the bobbin exactly at the same speed as that at which it is spun, was what tried the ingenuity of the machine makers. If the diameter of the bobbin were to remain always the same, it would have been comparatively an easy matter to have invented a mechanism to take up the rove as it was delivered from the roller, but its diameter is increased by every layer of rove that is put on it; so machinery was required to perform the following things:—

For illustration, we will say that the rollers deliver eighty inches in half a minute, and that the eighty inches, when wound upon the bobbin, (which is one inch in diameter, and seven inches long) makes one layer of rove from the one end of the bobbin to the other. The speed of the bobbin must be regulated to take up the eighty inches and no more, and the rail that bears the bobbin must pass through the space of seven inches in half a minute. The diameter of the bobbin is increased by the first layer, to such an extent, that the second layer requires a hundred inches of rove to complete it; so both the speed of the bobbin and the bobbin rail require to be altered proportionately, and the same with every extra layer of rove that is put upon the bobbin, until it is full, a different speed for every layer. The alteration of the speed requires to take place at the instant the second layer commences, and continues to run at a uniform rate until the third

layer begins, and so on, for, say twenty layers. The bobbin, before being filled, has had twenty different speeds; but this is not all the difficulty, because, if the rove which is to be made for the next filling of bobbins be only half the thickness, it will require, instead of twenty layers, forty, to fill the bobbin, and every one of the forty layers requires a different speed; and, as there are about sixty or seventy sizes of rove made for the different numbers of yarn that are spun, some idea can be formed of the immense number of different speeds required, and the importance of finding a combination of mechanism that would give such a variety of speeds.

To give the bobbin the proper speed for each layer, one machine maker had a pair of pinions for each speed. If it took thirty layers of rove to fill the bobbin, that was thirty pair of pinions required for that particular size of rove; one shaft had one half of the pinions fixed upon it, and another shaft had the other half of the pinions loose upon it. Each shaft had thirty pinions. The pinion with the greatest number of teeth in it was put on the shaft first, and all the others in rotation; the thirtieth—the smallest in the lot—being the last put on. By this arrangement, when the pinions were all close to one another, they formed a cone with thirty steps in it. The other thirty pinions were put on another shaft; the first pinion put on it was the smallest, and the last the

largest in diameter; so it also formed a cone with thirty steps. When the two cones were brought into contact, each pinion geared with the one opposite. The shaft with the pinions loose on it, had a groove cut longtitudinally on it, and, in this groove, a long slip of iron, with a small pin projecting outwards from the centre of the shaft, moved from the one pinion to the other. The pinions being all loose, none of them took effect on the shaft, except the one that was caught by the small pin on the slip of iron. So this pin was shifted from the one pinion to the other, at every ascent and descent of the bobbin rail, which changed the speed of the bobbin for the next layer.

It will be evident that, with this plan of getting all the various speeds that are requisite, an immense number of pinions would be required; but it had the advantage over the old plan, with the two plain cones and belt; by it not having any slippage, which frequently occurred when the belt got the least slack. The driving of the bobbins with a belt cannot be satisfactorily done, except in small frames where the power required is very little; so, to get the frame enlarged, some other plan had to be discovered that would not depend upon the power of a belt for driving the bobbins.

The best contrivance, for varying the speeds of the bobbins, is the one in which a pair of bevel wheels work inside the circumference of a spur wheel. This

pair of bevel wheels gear into another pair of the same diameter, which are fixed upon a driving and a driven shaft, and the spur wheel runs loose on the ends of the two shafts—the driver and the driven. There is a bevel wheel fixed on the driven shaft which gears into the pair on the spur wheel. These four bevel wheels are all in contact with one another, so that, when one moves, all the other three move at the same speed, if the spur wheel stands still; because the bevel wheels, inside the spur wheel, being loose on their studs, they make no alteration in the speed; but if any motion is given to the spur wheel, a different motion is given to the shaft that is driven. It is by the varying speed of the spur wheel that all the different velocities are given to the bobbin. The spur wheel is driven by a pinion on the end of the cone shaft, and the speed of the cone is regulated by a rack, which moves one tooth for every ascent and descent of the bobbin rail.

The shaft that drives the bobbins is carried up and down with the rail that bears the bobbins, and a small wheel is made fast upon it, for each spindle that is in the frame; this wheel gears with a pinion that runs loose upon the spindles, and the bobbin rests upon the pup of the pinion which is carried up and down with the rail. This shaft, that drives the bobbins, receives its motion from the shaft that is driven by the spur and bevel wheels already described; consequently, the bobbins partake of the same variations of speed along

with the shaft. The mechanism that causes the bobbin rail to move up and down, also receives its motion from the same shaft; so that, when the speed of the bobbins is altered, the speed of the bobbin rail is also changed by the same alteration — the one working in unison with the other.

These different things I have been describing about the speeds of the bobbin, and the traverse rail which bears the bobbins, must have an index of some kind by which they are regulated. One of them is a rack, or rather double rack, for it has teeth on both edges, and the number of teeth in it corresponds to the number of layers of rove that are required to fill the bobbin. If it requires twenty-five or thirty layers of the rove to complete the quantity wanted to be put on, then there must be twenty-five or thirty teeth on the rack, as the case may be. There is a different rack for each size of rove, unless there is a very little difference between the sizes of rove. When the carding master is changing the pinion, for the purpose of producing a different hank roving from what the machine was making before, he changes the rack also, putting on the one that has the requisite number of teeth in it to correspond to the number of layers.

The racks are, in general, made of cast iron, and the making of the patterns for them is a very particular piece of workmanship, and requires some nice calculations, if the work is to be done from the beginning.

But there are tables made out for the guidance of the pattern maker; also a machine for dividing the rack into a given number of spaces for the teeth, each tooth having a different space; that is, the space between the first tooth and the second, is less than that between the second and the third; and the space between the third and fourth is more than that between the second and third, and so on—the distance between each tooth becoming greater as they increase in number.

When the different tables are at the service of the pattern maker, and also the machine for dividing the teeth in the rack, all the instruction that it is requisite to give him, is to tell the quantity wanted, and the number of teeth that are to be made on each rack. As before stated, each layer of rove requires one tooth in the rack, so that the number of teeth in the rack will correspond to the number of layers of rove that are required to fill the bobbin. The number of layers required to fill the bobbin will be in proportion to the size of the rove; and the pattern maker, by looking at the table for the size wanted, will see the number of teeth that should be made in the rack; and he turns the dividing machine to suit that number.

The construction of the dividing machine, as far at least as the scroll is concerned, will depend upon the pitch of the cone, and each machine maker, who makes the fly frames, may have a form of cone to suit his own make of machine; and, when that is the case, the

scroll of the dividing machine must be made to answer the pitch of the cone, because the distances between the teeth in the rack, require to be made in accordance with the pitch of the cone.

The traverse of the bobbin rail is the same, up and down, from the time the first layer of rove is put on the bobbin until the finish of the last layer. But, when tubes are used instead of bobbins, it is different. What is meant here by tubes are those pieces of wood that the rove is built upon, which are just bobbins without the flange at each end. Some people give the name "spools" to both tubes and bobbins. The tubes having no flange to guide the building of the rove, it is built upon them in such a manner as that each end has a conical shape when the rove is all wound upon the tube. This cone shape is given to the rove by the traverse rail making a shorter traverse for each succeeding layer of rove. The first layer of rove covers the tube from one end of it to the other, except about three-eighths of an inch, which is the part where the notch is made for the pin that drives it, goes in. The second layer of rove has one turn of rove less upon the tube than the first, the third, one less than the second, and each succeeding layer, one less than the one immediately preceding it. The distance that the traverse rail makes less every layer, being divided between each end of the tube, causes the different plies of rove to embosom each other,

which makes the rove more firmly built upon the tube, than if one ply were put exactly on the top of the other. The difference of the space that the rail travels, each succeeding layer, depends upon the size of the rove. If the rove is a quarter of an inch in diameter, then the traverse will be a quarter of an inch less for each layer. If an eighth part of an inch in diameter be the size of the rove, then the traverse will be one-eighth of an inch less—the traverse being regulated according to the diameter of the rove.

These tubes for the fly frame, have, in a great measure, superseded the bobbins. They are found to suit the purpose of the spinners in many respects better than the bobbins. The first cost of the tubes is not more than one-third the price of the bobbins, and they last much longer. The expense of repairing the bobbins is very great, caused by the ends being broken, by them falling on the floor; whereas the tubes never get broken by falling. Another advantage the tubes have over the bobbins is, that the pressers can be applied with better effect.

At the time when the fly frame was introduced, the flyer had nothing attached to it to give any pressure to the rove, and the consequence was, that a very small quantity, compared to what can be put on at the present time, filled the bobbin. At first only one of the legs of the flyer had a spring attached to it to give the pressure to the rove. As time went on

a spring was put on each leg of the flyer. These flyers were named single and double "spring pressure flyers," to distinguish them from another kind called the "centrifugal force flyer." The rove that received its pressure from the centrifugal force had an equal pressure, from the time the bobbin began to fill until it was finished; but, with the spring flyer, the pressure upon the rove increased in proportion as the bobbin increased in diameter. With the pressure flyers, the quantity of rove put on to the tubes or bobbins is many times greater than what can be put on without them.

The introduction of the pressure flyers was the means of reducing the labour of the rove piecer, at the mules, to a great extent; also the throstle spinners were enabled to attend to a greater number of spindles, in consequence of the rove lasting much longer.

To ascertain the speeds of the different things about the fly frame, begin with the shaft in the carding room that drives the fly frame, and, after the number of revolutions of the fly frame shaft is found, the speed of the front roller, and the back one, can be traced for the purpose of finding the draught; and, to ascertain the twist, find the number of revolutions the spindles make in one minute, and the number of inches of rove that the front roller gives out in the same time. Then divide the revolutions of the spindles by the inches of rove, and the answer will be the number of twists per inch. It has already been shown how

these calculations are performed, so there is no need of repeating them.

Sometimes there is a certain amount of slippage in the belts, and, in making out the calculations, an error may be made without being noticed; so, to prove what is the exact amount of twist that is given to the rove, the workman drives the frame, with his hand, slowly enough to enable him to count the number of turns the spindles make in the time the front rollers give out six or eight inches of rove. He puts a mark upon the rove six or eight inches from the eye of the flyer, and, when the mark reaches the eye, he knows how many turns the spindles have made, and that is the number of twists given to the six or eight inches of rove. Suppose it is six inches he takes for the measure, and that the spindles have made twenty-four turns in the time taken to produce six inches, then there will be exactly four twists per inch upon the rove. This result can be compared with his calculations, and, if the two agree, it proves that the calculations are correct, and that there is no slippage.

In a medium sized fly frame the spindles may be driven at a speed varying from five hundred to five hundred and sixty revolutions per minute, and the speed of the front rollers will be regulated by the fineness of the rove that is being made at the time. The quantity of rove that a frame will produce, when the speed of the spindles is known, will be readily

ascertained by looking at the "Twist Tables" for hank roving, for the number of twists per inch; if the speed of the spindles be divided by the number of twists per inch, the product will be the number of inches of rove produced in one minute, and, by multiplying the inches of rove by the number of spindles in the fly frame, the gross quantity is found for one minute; and from this the quantity of hanks for one day or week can be calculated. A certain percentage must be allowed for stoppages, and every manager will have to find out for himself what that percentage should be, because it will altogether depend upon the kind of rove that is being made in the factory; in making low numbers more frequent stoppages are necessary for doffing, &c., than with the higher numbers. We will give an example to show how much rove a fly frame with one hundred and twenty spindles will produce in a week of fifty-eight hours. Say the spindle makes 540 revolutions per minute, and that there are three twists on the inch of rove.

EXAMPLE No. 3.

```
Twist per inch,  3)540   revolutions of spindles.

                   180   inches of rove.
                   120   spindles in frame.
                  ----
                  3600
                  180
                  -----
Inches in yard  36)21600(600   yards in one minute.
                  216
```

From the foregoing figures it will be seen that the frame produces six hundred yards of rove in one minute; so, by multiplying the six hundred by sixty, and the product by fifty-eight hours, the gross quantity will be found for a week.

EXAMPLE No. 4.

```
                          600 yards.
Minutes in one hour        60

                        36000
                           58

                       288000
                      180000
                      -------
Yards in hank  840)2088000(2485  hanks in one week.
                      1680

                       4080
                       3360
                       ----
                        7200
                        6720

                         4800
                         4200
                         ----
                          600
```

To find the weight in pounds, divide the hanks by the number of hank roving, which will be about No. 5 for three twists per inch.

EXAMPLE No. 5.

```
Hanks in one pound  5)2485  hanks.
                      ----
                       497  pounds of rove in one week.
```

Now, suppose the machine was making rove with six twists per inch, the number of hanks produced, in one week, would be only one half or 1242½ hanks. But it is a great deal less than a half in pounds, because rove, with six twists per inch, will be No. 22ˢ or 22 hanks in the pound.

EXAMPLE No 6

```
Hanks in pound   22)1242 50(56 47   pounds.
                    110
                    ---
                     142
                     132

                      105
                       88
                      ---
                       170
                       154
                       ---
                        16
```

This shows that the produce of the frame in one week is only about 56½ lbs. of No. 22ˢ rove.

From the foregoing remarks, it will be evident that by reducing the twist upon the rove or slub, the production will be increased in proportion, and it has already been shown, that the only use for twist upon slub or rove is to give sufficient strength to enable it to support its own weight, and turn the tubes in the creel. If, by some means, the tubes could be made to turn without putting any strain whatever upon the rove, then less than one half the twist would be

sufficient to support itself; consequently, by reducing the twist one half, the production of these machines would be doubled.

This increase of production could be accomplished by a very simple change in the creels. At present the tubes are placed in the creels in an upright position, and, although very little power is required to keep them going after they are set in motion, there is a considerable amount of strain put upon the rove to start the tubes, especially when they are filled with rove or slub. It is to do away with all the power exerted by the rove that I propose this alteration.

The tubes are placed in the creels in a horizontal position. The skewer is put through the tube for the purpose of guiding it and keeping it in its proper place, and the tube with the rove on it, rests upon a roller the diameter of which may be the same as the diameter of the backmost roller in the fly frame. This roller, that the rove lies upon, is driven at the same speed as the back roller of the fly frame, and will deliver the rove to the back rollers at the exact speed required, so that there will be no strain upon the rove—the tubes being driven by what I will call the creel roller. It is not requisite that the creel roller should be made with the same diameter as the back roller in the fly frame, but, whatever the diameter may be, the speed of the circumference of it, must be exactly the same as that of the back roller of

the fly frame, because it is the creel roller that gives out the rove.

In preference, I would recommend that the creel roller be nine eighths of an inch in diameter, as that size will be large enough to give a sufficient hold of the rove to enable it to turn the tube. If the rove is to be put into the creel from the back, which is the case with the mule, the slits for guiding the skewers will be made with an incline towards the back. But, if it is put in from the front, as done at the throstle frame, then the slits will have an incline towards the front. The reason for having the slits made in the inclined position is, that the rove will be more easily put into the creel, and a little less space will be required than if they were made perpendicular.

There will be a roller for every tier of rove, and each tube will have a separate place in the creel, and it will make no difference as to the diameter of the tube when it is filled with rove, as regards the speed that the rove will be delivered at, because the tubes, being driven from the surface of the rove, the same quantity is given out, whether the tube be full or half full of rove. By adopting this plan for driving the slub or rove, the yarn will be made more evenly, being free from the small pieces which cause the yarn to be what is called "clouded." This clouding is frequently caused by the strain put upon the rove in turning the tube. It has often been observed, that

yarn spun by the throstle frame is more evenly than that spun by the mule, and there is no doubt that one of the reasons is the frequent stopping and starting of the rove tubes in the mule, which cause the yarn spun by the mule to be more uneven than that spun by the throstle.

Of course the adoption of this plan will cause a certain amount of expense in the alteration of the creels, but it will be a mere trifle compared to the saving it will effect, for the slubbing and fly frames will, at a low estimate, produce double the quantity, and only half the number of the machines will be required; so that there will be a saving in engine power, workers' wages, oil, belting, &c. But, when new factories are being put up, another saving will be made in the first cost of the machines, and of floor space in the carding room. (See end of Chapter VII.)

Setting the rollers in the fly frame to suit the length of staple, is done in the same manner as in the drawing frame—a process already explained—the only difference being that, at the drawing frame, no twist has been given to the sliver. But, when it has passed through the slubbing frame, and has received twist before it comes to the fly frame, this twist must also be taken into consideration in setting the stands, to give the rollers the proper distance between each other; because, the fibres of the cotton will not separate from each other as readily, as when no twist is on them.

THE THROSTLE FRAME.

Although Hargreave's spinning machine, was in operation before Arkwright had completed the throstle, (known by the name "water frame") yet it was the throstle frame that made the first good yarn, and the first spinning machine that was propelled by mechanical power—animal power being used previous to Arkwright applying a water-wheel for driving his spinning machines. For that reason we select it as the subject of our first remarks upon spinning machines.

In the second chapter some remarks have been made about the original throstle (or water frame), and its improvement. These need not be repeated. Since Arkwright's time, many machines, differing from one another in some particular parts, have been tried. Some of these have succeeded, and others have been put out, not having answered the purpose the inventors had intended. The very best throstle frames of the present day are, as far as the principle is concerned, the same as that invented by Arkwright; viz.: the drawing out of the rove to the degree of fineness required for the intended yarn, and the twisting of it by spindles, which do not recede from the rollers. It is true that, in some of the machines that have been made, the spindle stands still, and it is the bobbin that revolves to give the twist, but that does not avoid the original principle.

There was a machine made in Manchester, which was the most unlike the original, or the present throstles, of any that I have seen. When I saw it, it was in the machine maker's shop working. The only name that I have heard applied to it is "the circular throstle." The framing was about eight feet in diameter, consisting of two cast-iron rings of the same size, the one placed above the other, ten or twelve inches apart, for supporting the spindles. The rollers were arranged round the frame, forming twenty-four sets or stands, and the couplings used for joining them, were made to answer the angle at which the one stood in relation to the other. What was intended as an improvement in this frame, was the way in which the bobbins were driven. A wheel with a rim about as large in diameter as the frame, was placed in the centre of the frame, and the edges of the bobbins rested upon the edge of the rim of this large wheel, and, when the frame was put in motion, the wheel turned the bobbins. The diameter of the wheel was so large compared to the size of the bobbins, that one revolution of the wheel gave about ninety to the bobbins. It would appear that this machine did not succeed, for it has not been taken up by the trade, notwithstanding all the noise made about its superority over all the others, at the time that it was being shown off to the spinners.

For the last thirty years, nearly all attempts to

improve the throstle, have been made for the purpose of increasing the speed of the spindles, for, by whatever means the speed of them can be increased, the production is greater in proportion. The two machines that are most approved of by the trade, at present, are, the one that has a hollow tube in the traverse rail on which the bobbin runs, the tube acting as a journal for the neck of the spindle, and that frame which is called the "ring throstle." The speed of both these frames is much higher than the ordinary throstle.

Some notice will be taken, in another place, of the improvements in throstle spinning.

The general mode of placing the throstle frames in the factory is across the flat, that is, the ends of the frames are set towards the windows of the building, and, when the building is wide, there are two frames in the breadth of the flat, and the ends of the frame, where the driving gear is fitted on, is placed in the centre. In some factories, in which throstle spinning is carried on, the upright shaft for conveying the power to each flat is at the end of the mill. This upright shaft propels one that extends from one end of the flat to the other; and a small cross shaft, with two pulleys on it, for each pair of frames, is driven by the long shaft; and the power is carried to the throstle by a belt, in the common way.

There is another way for driving the throstle frames which looks very well, having no cross shafts for each

pair of frames, but, instead, another long shaft; that is, there are two shafts that extend from the one end of the flat to the other, the one right above the other. There is one pulley on each of the shafts for every pair of frames; by this way of arranging the gearing one belt drives both machines, the belt passing over one of the shafts, then down to the pulleys on the frame, and up and over the other shaft, and then down to the other frame. When the frames are driven in this manner, there is a space between the ends of the frames, corresponding to the diameter of the pulleys on the driving shafts. This space is as large as will allow a person to walk between the ends of the frames, from the one end of the flat to the other. This plan of driving the throstles is thought, by some, to be better than the other way, but is objected to by others because the belts are not so easy to manage, and have a half twist, which is an objection, though a small one.

With a good make of throstle, the spindles can be driven, with safety, at a speed of five thousand four hundred revolutions per minute. I have already given examples of how to find the speeds of the different shafts, from the engine until the power is brought into the flat of the main building. We will say that the number of revolutions the shaft which drives the throstle frame makes, is two hundred and twenty, and the pulley on it for driving the cylinder

is twenty-five inches in diameter, and the diameter of the cylinder pulleys are nine inches; the cylinder being eight and three quarters of an inch, so, by the usual way of calculating, the number of revolutions that the spindles will make in one minute, will be found. The wharve on spindle is one inch.

EXAMPLE No. 7.

```
                Speed of shaft          220
                Diameter of pulley       25
                                       ----
                                       1100
                                       440
                                       ----
Diameter of pulley on cylinder 9)5500(611 speed of cylinder.
                                       54
                                       ---
                                        10
                                         9
                                        --
                                        10
                                         9
                                        --
                                         1
                                         9
                                        --
                 Speed of cylinder      611
                 Diameter of cylinder  8·75
                                       ----
                                       3055
                                      4277
                                     4888
                                     -----
          Diameter of wharve 1)5346·25( speed of spindles.
```

This shows the number of revolutions the spindles will make in one minute to be 5346·25.

There are, in the trade, many throstles, the spindles of which are driven at a much greater speed, but we

have taken this number as a medium speed, and it will suit our purpose as well as any other as to the calculations. In a number of throstle frames, there are two cylinders, the one placed right above the other, and the one band drives two spindles. But, as far as the speed is concerned, they act as one cylinder, and make no difference in the mode of calculation for finding the speed of the spindles. The plan with the two cylinders is adopted principally for the purpose of getting the frames made narrower to save floor space.

To ascertain the number of revolutions the front rollers will make in one minute, begin with the pinion on the axle of the cylinder, which is the first driver, and multiply the number of revolutions the cylinder makes in one minute, by the number of teeth in that pinion, then divide the product by the number of teeth in the wheel that the pinion drives; this will give the number of revolutions that the wheel makes in one minute. It is on this first wheel that the change pinions are put; and it is the change pinion that gives motion to the wheel that drives the front rollers. Before the size of the change pinion can be known, the twist that is to be put upon the yarn must be decided. When the number of teeth that are to be in the change pinion is fixed upon, that will give the requisite twist, multiply the revolutions of the wheel by the number of teeth in the change pinion, and divide the product by the number of teeth in the wheel that is on the end

of the front roller, and the answer will be the number of revolutions the front rollers make in one minute.

If the yarn requires to have eighteen twists per inch, that is eighteen turns the spindle will have to make to give that twist. It has been seen that the speed of the spindles is five thousand three hundred and forty-six; this, divided by eighteen, will give the number of inches of yarn that will be spun in one minute.

EXAMPLE No 8.

```
Twist per inch   18)5346(297   inches of yarn in one minnte.
                    36
                    ---
                    174
                    162
                    ---
                     126
                     126
                     ---
```

The diameter of the front roller is one inch, so that its circumference will be fully more than three inches and an eighth; but the fraction above that is so small that it may be omitted in the calculations. By dividing the inches of yarn produced in one minute, by the circumference of the front roller, the answer will be the revolutions of the front roller per minute.

EXAMPLE No. 9.

```
Circumference of roller 3·125)297·00(95 04  revolutions of front
                              28125                    [roller.
                              -----
                               15750
                               15625

                                 12500
                                 12500
```

This makes the speed of the rollers to be 95·04 per minute, and we have found the speed of the cylinder to be 611 revolutions. The following will show how it is figured out in the simplest way:—

EXAMPLE No. 10.

```
           Speed of cylinder   611
   Teeth in pinion on cylinder  32
                              ----
                              1222
                             1833
                             -----
Teeth in first wheel  90)19552(217·244 revolutions of first
                         180                         [wheel.
                         ---
                          155
                           90
                          ---
                           652
                           630
                           ---
                            220
                            180
                            ---
                             400
                             360
                             ---
                              400
                              360
                              ---
                               40
```

This gives 217·244 revolutions for the first wheel and the change pinion that will give the nearest speed to 95·04 has thirty-nine teeth, which, as will be seen from the following example, gives a speed to the front roller of 94·139:—

EXAMPLE No. 11.

```
Revolutions of first wheel   217·244
             Change pinion        39  teeth.
                             -------
                             1955196
                             651732
                             -------
Teeth in front roller wheel 90)8472516(94·139  speed of front
                             810                   [roller.
                             ---
                              372
                              360
                              ---
                               125
                                90
                               ---
                                351
                                270
                                ---
                                 816
                                 810
                                 ---
                                   6
```

These calculations are principally required at the starting of a new factory, or when new throstles are being put into an old one. For when the mill is in full operation the spinning master, when changing the twist, has just to ascertain the number of twists that the yarn requires by looking at the twist table; and, as he knows that eighteen twists per inch require a pinion of thirty-nine teeth, he finds the pinion for any other twist by simple proportion. If eighteen twists require a pinion with thirty-nine teeth, what will twenty-four twists require? The pinion for twenty-four will have fewer teeth than the one for eighteen.

EXAMPLE No. 12.

```
Twist per inch  18  :  39  :  24
                       18
                      ----
                      312
                      39

                   24)702(29
                      48

                      222
                      216
                      ---
                        6
```

The twist required for slub or rove, is comparatively little to that which is requisite for yarn. If the rove has sufficient strength to turn the bobbin, no more is needed, but with yarn for warps, it must have strength to stand the strain that is put upon it when in the process of weaving. The material that would make first-rate yarn, if the proper quantity of twist had been given, is often rendered useless for warps for want of a sufficiency of twist. It is seldom spoiled by too much twist, but it can be, hence the necessity of having some fixed standard, for the different kinds of yarn, for the guidance of the spinning master.

The quantity of twist given to yarn is varied according to the purpose for which the yarn is intended. The following tables give the twist per inch for three qualities of warp, and also for three qualities of weft. Although every size of yarn is not put in the tables, the numbers given are all that are required in practice. In the higher counts we have only given one in ten, because it takes about ten numbers to alter the twist one turn per inch.

TWIST TABLE FOR SUPERIOR WARPS.

No.	Sq. Root.	Twist per inch.	No.	Sq. Root.	Twist per inch.
1	1·000	3·80	85	9·219	35·03
2	1·414	5·37	90	9·486	36·04
3	1·732	6·58	95	9·746	37·03
4	2·000	7·60	100	10·000	38·00
5	2·236	8·69	110	10·488	39·85
6	2·449	9·30	120	10.954	41·62
7	2·645	10·05	130	11·404	43·33
8	2·828	10·74	140	11·832	44·96
9	3·000	11·40	150	12·247	46·53
10	3·162	12·02	160	12·649	48·06
11	3·316	12·60	170	13·038	49·54
12	3·464	13·16	180	13·416	50·98
14	3·741	14·21	190	13·784	52·37
16	4·000	15·20	200	14·142	53·73
18	4·242	16·11	210	14·491	55·05
20	4·472	16·99	220	14·832	56·36
22	4·690	17·82	230	15·165	57·62
24	4·898	18·61	240	15·491	58·86
26	5·099	19·37	250	15·811	60·08
28	5·291	20·10	260	16·124	61·27
30	5·477	20·81	270	16·431	62·43
32	5·656	21·49	280	16·733	63·58
36	6·000	22·80	290	17·029	64·71
40	6·324	24·03	300	17·320	65·81
45	6·708	25·49	310	17·606	66·90
50	7·071	26·86	320	17·888	67·97
55	7·416	28·18	330	18·165	69·02
60	7·745	29·43	340	18·439	70·06
65	8·062	30·63	350	18·708	71·09
70	8·366	31·79	360	18·973	72·10
75	8·660	32·90	370	19·235	73·09
80	8·944	33·98			

TWIST TABLE FOR MEDIUM WARPS.

No.	Sq. Root.	Twist per inch.	No.	Sq. Root.	Twist per inch.
1	1·000	3·50	85	9·219	32·26
2	1·414	4·94	90	9·486	33·20
3	1·732	6·06	95	9·746	34·11
4	2·000	7·00	100	10·000	35·00
5	2·236	7·82	110	10·488	36·70
6	2·449	8·57	120	10·954	38·33
7	2·645	9·25	130	11·404	39·91
8	2·828	9·87	140	11·832	41·41
9	3·000	10·05	150	12·247	42·86
10	3·162	11·06	160	12·649	44·27
11	3·316	11·60	170	13·038	45·63
12	3·464	12·12	180	13·416	46·95
14	3·741	13·09	190	13·784	48·24
16	4·000	14·00	200	14·142	49·49
18	4·242	14·78	210	14·491	50·71
20	4·472	15·65	220	14·832	51·91
22	4·690	16·41	230	15·165	53·07
24	4·898	17·14	240	15·491	54·21
26	5·099	17·84	250	15·811	55·33
28	5·291	18·[illegible]	260	16·124	56·43
30	5·477	19·1[illegible]	270	16·431	57·50
32	5·656	19·[illegible]7	280	16·733	58·56
36	6·000	21·00	290	17·029	59·60
40	6·324	22·13	300	17·320	60·62
45	6·708	23·47	310	17·606	61·62
50	7·071	24·74	320	17·888	62·60
55	7·416	25·95	330	18·165	63·57
60	7·745	27·10	340	18·439	64·53
65	8·062	28·21	350	18·708	65·47
70	8·366	29·28	360	18·973	66·40
75	8·660	30·31	370	19·235	67·32
80	8·944	31·30			

TWIST TABLE FOR SOFT WARPS.

No.	Sq. Root.	Twist per inch.	No.	Sq. Root.	Twist per inch.
1	1·000	3·30	85	9·219	30·42
2	1·414	4·66	90	9·486	31·30
3	1·732	5·71	95	9 746	32·16
4	2·000	6 60	100	10·000	33·00
5	2·236	7·37	110	10·488	34·61
6	2·449	8·08	120	10·954	36·14
7	2·645	8·72	130	11·404	37·63
8	2·828	9·33	140	11·832	39·04
9	3·000	9·90	150	12·247	40·41
10	3 162	10·43	160	12·649	41·74
11	3·316	10·94	170	13·038	43·02
12	3·464	11·43	180	13·416	44·27
14	3·741	12·34	190	13·784	45·48
16	4·000	13·20	200	14·142	46·66
18	4·242	13·99	210	14·491	47·82
20	4·472	14·75	220	14·832	48 94
22	4·690	15·47	230	15·165	50·04
24	4 898	16·16	240	15·491	51·12
26	5·099	16·83	250	15·811	52·17
28	5·291	17·46	260	16·124	53·20
30	5·477	18·07	270	16·431	54·22
32	5·656	18 66	280	16·733	55·21
36	6·000	19·80	290	17·029	56·19
40	6·324	20·86	300	17·320	57·15
45	6·708	22·13	310	17·606	58·09
50	7·071	23·33	320	17·888	59·03
55	7·416	24·47	330	18·165	59·94
60	7·745	25·55	340	18·439	60·84
65	8·062	26·60	350	18·708	61·73
70	8·366	27·60	360	18·973	62·61
75	8·660	28·57	370	19·235	62·47
80	8·944	29·51			

TWIST TABLE FOR HARD SPUN WEFTS.

No.	Sq. Root.	Twist per inch.	No.	Sq. Root.	Twist per inch.
2	1·414	4·80	85	9·219	31·34
3	1·732	5·88	90	9·486	32·25
4	2·000	6·80	95	9·746	33·13
5	2·236	7·00	100	10·000	34·00
6	2·449	8·32	110	10·488	35·65
7	2·645	9·09	120	10 954	37·24
8	2·828	9·60	130	11·404	38·77
9	3·000	10·20	140	11·832	40·22
10	3·162	10·75	150	12·247	41·63
11	3·316	11·27	160	12·649	43·00
12	3·464	11·77	170	13·038	44·32
14	3·741	12·71	180	13·416	45·61
16	4·000	13·60	190	13·784	46·86
18	4·242	14·42	200	14·142	48·08
20	4·472	15·20	210	14·491	49·26
22	4·690	15·94	220	14·832	50·42
24	4·898	16·65	230	15·165	51·56
26	5·099	17·33	240	15·491	52·66
28	5·291	17·98	250	15·811	53·75
30	5·477	18·62	260	16·124	54·82
32	5·656	19·23	270	16·431	55·86
36	6·000	20·40	280	16·733	56·89
40	6·324	21·50	290	17·029	57·89
45	6·708	22·74	300	17·320	58·88
50	7·071	24·04	310	17·606	59·86
55	7·416	25·21	320	17·888	60·81
60	7·745	26·33	330	18·165	61·76
65	8·062	27·41	340	18·439	62·69
70	8·366	28·44	350	18·708	63·60
75	8·660	29·44	360	18·973	64·50
80	8·944	30·40			

TWIST TABLE FOR MEDIUM SPUN WEFTS.

No.	Sq. Root.	Twist per inch.	No.	Sq. Root.	Twist per inch.
2	1·414	4·52	85	9·219	29·50
3	1·732	5·53	90	9·486	30·35
4	2·000	6·40	95	9·746	31·18
5	2·236	7·15	100	10·000	32·00
6	2·449	7·83	110	10·488	33·56
7	2·645	8·46	120	10·954	35·05
8	2·828	9·04	130	11·404	36·49
9	3·000	9 60	140	11·832	37·86
10	3·162	10·11	150	12·247	39·19
11	3·316	10·61	160	12·649	40 47
12	3·464	11·08	170	13·038	41·72
14	3·741	11·97	180	13·416	42·93
16	4·000	12·80	190	13·784	44·10
18	4·242	13·57	200	14·142	45·25
20	4·472	14·31	210	14·491	46·37
22	4·690	15 00	220	14·832	47·46
24	4·898	15·67	230	15·165	48·52
26	5·099	16·31	240	15·491	49·57
28	5·291	16·93	250	15·811	50·59
30	5·477	17·52	260	16·124	51·59
32	5·656	18·09	270	16·431	52·57
36	6·000	19·20	280	16·733	53·54
40	6·324	20·23	290	17·029	54·49
45	6 708	21·46	300	17·320	55·42
50	7·071	22·62	310	17·606	56·33
55	7·416	23·73	320	17·888	57·24
60	7·745	24·78	330	18·165	58·12
65	8·062	25·79	340	18·439	59·00
70	8·366	26·77	350	18·708	59·86
75	8·660	27·71	360	18·973	60·71
80	8·944	28·62			

TWIST TABLE FOR SOFT SPUN WEFTS.

No.	Sq. Root.	Twist per inch.	No.	Sq. Root.	Twist per inch.
2	1·414	4·24	85	9·219	27·65
3	1·732	5·19	90	9·486	28·45
4	2·000	6·00	95	9 746	29·23
5	2·236	6·70	100	10·000	30·00
6	2·449	7·34	110	10·488	31·46
7	2·645	7·93	120	10·954	32·86
8	2·828	8·48	130	11·406	34·21
9	3·000	9·00	140	11·832	35·49
10	3·162	9·48	150	12·247	36·74
11	3·316	9·94	160	12·649	37·94
12	3·464	10·39	170	13·038	39·11
14	3·741	11·22	180	13·416	40·24
16	4·000	12·00	190	13·784	41·35
18	4·242	12·72	200	14·142	42·42
20	4·472	13·41	210	14·491	43 47
22	4·690	14·07	220	14·832	44 49
24	4·898	14·49	230	15·165	45·49
26	5·099	15·29	240	15·491	46·47
28	5·291	15·87	250	15·811	47·43
30	5·477	16·43	260	16·124	48·37
32	5·656	16 96	270	16·431	49·29
36	6·000	18·00	280	16·733	50·19
40	6·324	18·97	290	17·029	51·08
45	6·708	20·12	300	17·320	51·96
50	7·071	21·21	310	17·606	52·81
55	7·416	22·24	320	17·888	53·66
60	7·745	23·23	330	18·165	54·49
65	8·062	24·18	340	18·439	55·31
70	8·366	25·09	350	18·708	56·12
75	8·660	25·98	360	18·973	56·91
80	8·944	26·83			

The plan I have taken to make out the foregoing twist tables is as follows:—The square root is found of the different sizes of yarn, and multiplied by a given number. The numbers taken are as follows:—

For Superior warps, - - - -	3·80
Medium „ - - - - -	3·50
Soft spun „ - - - - -	3·30
Hard spun wefts, - - -	3·40
Medium „ „ - - - -	3·20
Soft „ „ - - - -	3·00

Suppose that the yarn to be made is No. 50^s superior warps, the square root of fifty is 7·071 and a small fraction more, but, as formerly stated, the fraction is confined to three decimal figures.

EXAMPLE No. 13.

$$\begin{array}{r} 7{\cdot}071 \\ 3{\cdot}80 \\ \hline 565680 \\ 21{\cdot}213 \\ \hline 26{\cdot}86980 \end{array}$$

By taking off the three figures at the right hand there is 26·86 left, which is the twist upon the yarn (nearly 27 twists per inch.)

If the yarn was No. 50^{s} medium wefts, the twists per inch would be 22·62, as will be seen from the following:—

EXAMPLE No. 14.

```
   7·071
    3·20
  ------
  141420
 21213
 -------
22·62720
```

This shows that the superior warps of number fifties have fully four twists per inch more than what is given to number fifties of medium wefts. The decimal figures, in the square root, are confined to three deep, being quite enough for the purpose; and the number of twists per inch is carried to only two decimal figures, which will be found to be as nearly correct as it can be got by the change pinions, because the smallest alteration that can be made, more or less, is one tooth. These tables will give the spinning master a standard to go by, but he may sometimes find it requisite to deviate a little from them to give certain kinds of yarn rather more or less twist than what is given in the tables.

The draught given to the rove at the throstle frame is done by making the back roller turn slower than the front one. The difference between the speed of them being the draught which varies from two inches up to ten or twelve. On the front roller is a pinion which is the driver for the crown wheel, and on the pup of the crown wheel is a pinion called by some the "grist pinion," because it is by the changing of this pinion that the size of the yarn is changed.

It is the grist pinion that drives the back roller, and as it varies in its diameter, according to the number of teeth in it, provision is made so that the two pinions and the two wheels can be kept in pitch with each other. This is accomplished by having the slit for the stud of the crown wheel made a segment of a circle, the radius, or half diameter of the circle, being equal to half the diameter of the crown wheel and the small pinion on the front roller added together. By having the slit made in this way it does not alter the pitch of the crown wheel and the pinion on the front roller, whatever position the stud is shifted to in the slit to suit all the different diameters of the pinions.

When the rollers have been placed in their position to suit the staple of cotton that is to be spun, and the pinion put on the crown wheel, which will give the draught required for the size of yarn wanted, the length of that draught can be found in the following way:—Multiply the speed of the front roller by the number of teeth in the pinion that is on the front roller, and divide the product by the number of teeth in the crown wheel. Then multiply the revolutions of the crown wheel by the number of teeth in the change pinion, and divide the product by the number of teeth in the back roller wheel. The answer will be the number of revolutions the back roller will make in one minute. At present we will suppose that the

front roller and the back one are of the same diameter. We will take the speed of the front roller to be ninety-four revolutions per minute.

EXAMPLE No. 15.

```
Revolutions of front roller  94
      Teeth in roller pinion  21
                              --
                              94
                             188

Teeth in crown wheel  80)1974(24·675  revolutions of crown
                         160                            [wheel.
                         ---
                          374
                          320

                           540
                           480
                           ---
                            600
                            560
                            ---
                             400
                             400
```

The revolutions of the crown wheel are 24·675 per minute. This number is multiplied by the teeth in the change (or grist) pinion, which we will say is twenty-eight.

EXAMPLE No. 16.

```
Revolutions of crown wheel  24·675
      Teeth in change pinion    28
                            ------
                            197400
                            49350
                            ------
Teeth in back roller wheel 60)690900(11·515 revolutions of back
                              60                        [roller.
                              --
                               90
                               60
                               --
                               309
                               300
                               ---
                                 90
                                 60
                                 --
                                 300
                                 ---
```

The revolutions of the front roller are divided by the number of revolutions of the back one, for the draught (the teeth given for the pinions and wheels may be different in the machines that are made by the various machine makers, but the principle in finding the speed are the same in all).

EXAMPLE No. 17.

```
Revolutions of back roller 11·515)94·000(8·163 draughts.
                                  92·120

                                   18800
                                   11515
                                   -----
                                    72850
                                    69090
                                    -----
                                     37600
                                     34545
                                     -----
                                      3055
```

The foregoing shows the draught to be eight inches and about one sixth of an inch, on the supposition that the rollers are the same diameter; but if the back roller be seven-eighths of an inch, and the front one eight-eighths, or one inch in diameter, their different circumferences will require to be taken into calculation.

In a former chapter it is shown how the circumference is found from the diameter, and need not be again explained.

The spinning master receives from the carding master a list, stating the size of rove that is made for each system, and, knowing the kind of yarn that is to be spun from that rove, he makes his calculations accordingly. If the change from one number of rove to another, be so small that it is not necessary to empty all the creels of the rove, the spinning master watches the new rove as it comes forward, and causes it all to be taken to one frame, allowing the old rove to be wrought up with the other frames; and when he thinks that half of the rove in the machine is the new kind, he puts on the pinion that will give the number wanted. He has previously tried the new rove on seven spindles, and has tested the yarn spun from it, so that he knows exactly what pinion to put on. But if the change in the size is great, the throstle frame is stripped of all the rove that is in it; that is, the old rove is taken out, and replaced with the new

rove. One frame after another is "stripped" until the whole system is changed. Suppose that an order is given to spin No. 30^s of a superior quality, the carding master is told to prepare five-hank roving for it, which rove will only require six inches of a draught to make No. 30^s. By having five-hank rove instead of four-hank the quality of the yarn is very much improved; because the four-hank would require a draught of seven inches and a half, and that would reduce the quality of the yarn. Although seven inches and a half is not a great draught to give at the throstle, it will not make so good yarn as a draught of six inches, but it will also make the yarn cost more; because, one spyndle of rove with a six inch draught will give only six spyndles of yarn, whereas, with a seven and a half inch draught there will be seven and a half spyndles of yarn. So, it is obvious, that with an extra amount of twist upon the yarn, and a short draught in the rove, the price of the yarn will be considerably enhanced.

It is not necessary at every change, to go through all the calculations, to find what number of teeth the change pinion should have, to give the proper draught, nor for the pinion that will give the requisite number of twists per inch. The spinning master may have tables made out for each, which will save a great amount of trouble in making out calculations, which he will require to do if there are no tables to refer to.

The copping rail, or, (as it is sometimes called) the bobbin bearer, traverses up and down, for the purpose of allowing the yarn to be regularly wound on the bobbin. The shaft that gives the traverse motion to the rails is regulated according to the size of the yarn, the speed of it being altered when the pinion is changed that gives motion to the rollers, which pinion is the twist pinion. Consequently, when coarse numbers are being spun, they require fewer twists per inch, and the rollers are driven at a greater speed, and the speed of the traverse motion is increased in proportion, so that no other change is required as regards the speed of the copping rail. If it is the "heart" that is used to give the traverse to the bobbins, it can be so shaped in the making of it, that the yarn can be wound on the bobbins at a uniform rate from the one end of the bobbin to the other; or, it can be made so as the yarn will be wound on the bobbins, so that when the bobbins are full, they will be considerably thicker in the centre than at the ends (barrel shape). This is done by making the traverse rail move more slowly when the yarn is being wound on the centre of the bobbins, and increasing in speed as it recedes from the centre toward the ends of the bobbin. This form of build cannot be so easily done when the mangle wheel is employed to give the traverse. For various reasons, it is better to have the yarn built upon the throstle bobbins with a larger diameter in the

centre than at the ends. One reason is, that when the bobbins are full of yarn, they are not so apt to ravel, (that is, the yarn coming over the ends of the bobbin); and another reason is, that the bobbin will hold more yarn.

It might be said that you cannot put more yarn on than the legs of the "flyer" or the ring will allow. That is true, but unless the ends of the bobbin be made as large in diameter as will fill the "ring," or the space between the legs of the "flyer," that quantity cannot be put on, and it would be very objectionable to have the ends of the bobbins made that size; therefore, it is better to use the small ended bobbins, and build the yarn "barrel shape."

The old method of oiling the throstle spindles occupied a great deal of time. So much so, that a number of workers, for an ordinary sized room, was kept for the purpose. A very important improvement has recently been made in this respect. At the step of the spindle there is a brass cup for holding the oil. It is so constructed, that when it is filled with oil, none of it flies off by the velocity of the spindles, and I have been told that one filling of the cups will keep the steps in oil for a week. The neck of the spindle is kept lubricated by a collar that retains sufficient oil to serve for a day or two. This is a great improvement over the old system, which made it requisite to oil the spindles several times each day, and at each oiling a

certain quantity was thrown upon the floor. To prevent the oil flying from the steps of the spindle, they were covered with wood, and after a time the wood was superseded by small brass covers, which did better, but still there was a certain amount of the oil thrown out.

When the throstle frame is all fitted up, the bands put on, and the other parts adjusted, it is ready for spinning. The "tying" of the bands is an operation that requires to be very carefully done, and no one can do it properly until they have practised it for some time. If they are made too tight, the power required to drive the spindles is very much increased, and the labour of piecing the ends is also increased. Then if they are made too slack, they slip upon the wharves, causing the yarn to lose so much of its twist. Therefore, it is only after the person has done it for several times that he knows the proper tightness.

The throstle spinners are, in general, girls, who begin to learn when about thirteen; but, before the Factory Act came into operation, many of them were not more than ten years of age when they were sent into the factory. In the course of a year or two these young girls get very expert at their work, which is to put the tubes, or bobbins, with the rove on them into the creel, then they take hold of the end of the rove and enter it into the back rollers. If the bobbins on the throstle spindle be empty, the worker takes

a bobbin full of yarn, and puts a yard or two upon each empty bobbin. This piece of yarn is joined to the rove, as it comes out of the front rollers, and the spinning commences. This operation is repeated until all the spindles on the frame are put into the act of spinning. If the bobbins when full are all "doffed" at the same time, (that is, the full bobbins taken off the spindles and empty ones put on), the "doffer" rolls as much yarn on the empty bobbins as is sufficient to start the refilling of them. When the frame is in full operation, the worker sees that all the bobbins in the creel have got rove on them, and when any one of them is nearly finished, she unrolls the little rove that is on the bobbin, and takes it out, putting a full bobbin in its place. She then unites the end of the new and old rove, and gives the bobbin a few turns to take up the slack rove. She has also to keep all the "ends up;" that is, to keep all the spindles making yarn. She has also to clean her "sides" several times each day. The body and gearing of the machine is kept clean by another set of workers, who are called "cleaners" or "doffers."

The making of good yarn does not depend much upon the throstle spinner, but a number of little faults, that sometimes happen to be on the yarn, can be prevented by the worker. These little faults, when numerous, give the yarn a bad character. Lumps on the yarn is a fault caused by bad piecing. The spinner takes

hold of the "end" (the word "end" in throstle spinning means the one thread which is being spun) with the finger and thumb, when she is going to join it to the rove coming out at the front rollers. If she presents the point of the end (without doubling it) to the fibres of the cotton, close to the front of the rollers, a proper joining or "piecing" will be made; but, if she turns her thumb towards the rollers, with the end doubled, the fibres are taken hold of by the yarn a little from its point, and a lump is made on the yarn. This is called "thumbing," and in some factories it is too much practised; for, although a number of the piecings may pass as good, yet the risk of making bad ones is very great. So that mode of joining the ends should be discouraged, also the working with dirty oily fingers.

The yarn should be a certain tightness between the eye of the "flyer" and the rollers. If it is too tight, the yarn will break away at the point where the fibres begin to twist at the front of the rollers. This can be prevented in two ways.—One way is to make the friction, that is on the bobbin, less, by cleaning the bottom of the bobbin; and, if that is not sufficient, by putting on a new washer. The other way is to put the "end" two or three times round the leg of the flyer. This causes friction, and makes the end less tight between the rollers and the eye of the flyer, in proportion to the number of turns put round the leg.

The friction on the bobbin is not decreased by this process, consequently, that part of the end, between the bobbin and the leg of the flyer, continues to have the same tightness. This is called "tempering" the end, and the worker soon learns, by the feel, when it is rightly tempered.

The end working too slack is also a fault, because, not being sufficiently stretched, it is more apt to curl when reeled, and it has a tendency to snarl in the spinning—that is, curling up at the eye of the flyer into a small bunch of tangled yarn, which is very annoying to the spinner. The cure for this is to put up the end without rolling it round the leg of the flyer, and if it is still too slack, to put a little oil on the bottom of the bobbin—the oil in this case causing more friction. The slackness of the end is frequently caused by the worker not cleaning that part of the spindle where the bobbin runs on, which should be done at the time the spinner takes off the full bobbin and puts on the empty one.

When an end is broken, and down for some time, the rollers continue to put out the drawn rove, and that accumulates on the roller beam, and is frequently caught by the ends that are next the broken one, and this makes a bad piece in the yarn. The worker should draw the bad piece off the bobbin, and piece the end anew; for, if it is not taken out by the spinner, it must be taken out by the winder, or some

other worker, whose hands it has to pass through, after it comes from the spinner.

There is a fault committed intentionally by the spinner, and should be severely checked. When an end breaks, and the spinner has some difficulty in finding it on the bobbin, she tears out a ply of the yarn, and breaks it, taking one of the ends of the broken bit to join to the rove. When this bobbin is being emptied, it is thrown aside by the worker when the broken bit is detected. It happens at times that wh n an end breaks, one of the bobbins or flyers next to it takes hold of the end, and winds it on along with the other to the bobbin. This is what is called "doubles," and the spinner should draw the double yarn off the bobbin, and piece the end anew.

All these faults can be prevented by carefulness on the part of the spinner; also, the following one:—If the spinner be careless, or overly busy, and a few of the ends remain "down" for a long time, the drawn rove frequently gets coiled round either the top roller or the under one. This is called "lapping." If the lap is allowed to increase to an extent that will lift one end of the top roller up, the rove at the other end will be put out from the rollers and twisted without being drawn. This causes a thick bit to be on the yarn. This thick piece will be long or short, according to the time that the rollers remain powerless to draw the rove. When the guide shifts the rove

nearer the end that is lapped, the rove is drawn, and proper yarn made until it recedes. Then again a thick piece of yarn is made. This continues while the lap is not removed, and, if the worker allows these thick pieces to remain on the bobbin, she is to blame, and at times a small deduction is made in her wages for the carelessness.

NEW PLAN FOR TEMPERING THE YARN.

To have all the ends working at their proper tension, is a very particular part of a throstle spinner's work, and a very large portion of her time is spent at every removal of the full bobbins, for it is seldom that the empty bobbins are exactly the same (as regards the drag) as those taken off; and at every "doffing" the end has to be tempered anew. I have already mentioned a number of the things that are to be done to give the end its proper tightness. One of them is the changing of the washers that are put under the bobbin; and if it were possible to know before taking the bobbin off the spindle, the exact diameter the washer should be to give the tension required, it would be a saving of the spinner's time, in trying to find out the right size. Even if she should chance to

put on the proper kind in the time that the bobbin takes to fill, the nature of it will, to a certain degree, be altered by the oil it receives off the spindle and the bottom of the bobbin. When the washer that is put under the bobbin is exactly the right size, the spinner does not require to put the end round the leg of the flyer, to make it slacker between the rollers and the eye of the flyer. Neither does she require to put oil on the washer, or the end of the bobbin, to make the end tighter. As the bobbin fills, the weight of it increases, and it would require a greater power to draw it forward, if its diameter remained the same; but its diameter increases along with its weight, and the one counterbalances the other, or very nearly. So that, when the end is properly tempered, after the commencement of the filling of the empty bobbin, it seldom requires any more adjustment, until the next "doffing" is performed.

The plan suggested, for the tempering of the ends, is to have a washer, or a substitute for one, that will answer for all the different kinds of bobbins, and which will give to a nicety the drag that is required. The tension given to the yarn is caused by applying friction to the bobbin, and friction is increased or diminished in proportion to the weight and velocity. Friction, in most cases, can be made less by applying a lubricating substance; but, in this case, when oil is applied to the bottom of the bobbin, it is increased,

because it makes the bobbin adhere to the woollen cloth. It has been shown that the weight of the bobbin need not be taken into consideration in this case; therefore, the drag must be regulated by the velocity—that is, the speed of the bottom of the bobbin. Instead of the common washer that the bobbin runs upon, there is a part of a washer, which we will call the friction plate, made of leather. It is about three-sixteenths of an inch broad, and may be any convenient thickness. There is a small screw-nut fixed in the friction plate, and the screw-pin attached to the nut which projects in front of the bobbin. On the end of the screw-pin that projects out, there is a brass ring, "narled" for the worker to turn the screw when she is giving the proper tension to the yarn. The material for the "friction plate" need not be confined to leather. It may be made of wood, brass, iron, or any other suitable substance.

The mode of action, in this new plan, is as follows: The bobbin rests upon the friction plate, instead of resting on the woollen washer, and the friction plate is in a slide which is fixed to the bobbin bearer, or traverse rail, and the friction plate is acted upon by the screw-pin. When it is close up to the spindle it is as near the centre of the under end of the bobbin as it can be, and will at that point have the least power over the bobbin. But, by turning the screw-pin, so that the friction plate will be drawn out from the

THROSTLE WITH INVERTED FLYERS.

When any attempt has been made to increase the speed of the spindles of the common throstle, beyond a given number of revolutions per minute, it has been found that the vibration of the spindles, was so much increased, that it spoiled the spinning. To cure this vibration, many different plans have been tried, and one of these was the inverted fly throstle (as it was called). In this machine, instead of putting the flyer on the top of the spindle, with its legs hanging down, it was screwed on to the end of a short hollow spindle, with its legs pointing upwards. The short hollow spindle was only four and a half inches long, and it ran in double bearings, with the wharve for driving it between the bearings. There was another spindle, not larger in diameter than a common mule spindle. This one worked inside the short hollow spindle, and on it the yarn was built. Above the centre of the spindle there was an eye made of wire, similar to the one used in the common throstle, when the flyers are made without tops for the end to pass through, and the end goes down through this eye to the turned up point of the leg of the flyer, and from this on to the spindle. At the same time that the flyer was giving twist to the yarn, it was winding it upon the spindle which came up through the hollow one. The

yarn could be wound either upon the bare spindle, or upon a bobbin or pirn, paper or cloth tube, by placing the particular one that was wanted upon the spindle. If it was spun upon a plain tube, or the bare spindle, the yarn was built in the form of a cop. If the yarn was intended for warps, the cops were made large in diameter; but if for wefts, that were to be used in the gray state, then the cops were made small in diameter, to suit the weaver's shuttle.

The steps of the spindles, on which the yarn was wound, rested on a rail that traversed up and down, the traverse being regulated to suit the kind of build required for the yarn. The apparatus for working the traverse rail could (as stated before) be altered to build the yarn on a bobbin; or to build it on the bare spindle, in the form of a cop. This spindle was dragged round by the flyer, and being light, with no friction to retard it, except its step, very little strain was put upon the yarn to turn it. The length of the cop could not be made longer than the leg of the flyer. When the yarn commenced to be built on the spindle, the traverse rail was full up, and its first movement downwards put the layer of yarn on to form the bottom of the cop.

It was anticipated by those that were in favour of the inverted flyer, that the following advantages would be gained over the common throstle:—The inverted flyer might be driven at a much higher speed, with

safety, than could be obtained from the common one. The yarn could be wound on a tube longer than the cop, and this would prevent any waste of the yarn, which occurs in the common cop, by being bent, or damaged at the point; and there would be no danger of stopping the cop when the worker was putting the skewer into it. Less power would be consumed in driving the throstle with the inverted flyer, because there would be less friction with the spindle and the tube, than with the bobbin; and that it would be capable of spinning any number from No. 120^s downwards—either warp or weft.

The advantage that this throstle had over the common one, for spinning fine numbers, was that no more strain was required to be put upon the yarn than merely to keep the end at the proper tension. The spindle was so easily turned that it had to be held back by something. Among the first things that were tried for this purpose was a small weight fixed to the end of a cord, and this cord was put almost round the spindle, and by increasing the angle of the cord to the spindle, more friction was applied to the spindle. Another way for adjusting the tension was by a fan (or vane) attached to the spindle, near the lower end of it. The vane was made so that the radius of it could be made larger or smaller at pleasure, to suit the tension of the yarn. The larger the vane was in diameter the greater was the resistance of the

air for retarding the spindle. It was in consequence of the small power that was required for driving the inside spindle, that this throstle could spin yarn so much finer than the common throstle.

MULE SPINNING.

We have already remarked that the mule is the invention of Samuel Crompton, and that it was introduced to the trade a number of years after Hargreave's jenny and Arkwright's water frame had been in operation. Although the mule is a combination of the jenny and water frame, it has not superseded the throstle (or water frame), but it completely put out of use Hargreave's jenny. Even supposing Crompton's mule had never been invented, Hargreave's jenny could not have been continued, because it would not have been able to compete with Arkwright's spinning machine, for the spinning of either warps or wefts. So we will pass over the spinning jenny, and give a few remarks about the mule.

The mule spinning machines are, in most factories, put in the upper flats of the building. When the building is sufficiently wide, the mules are placed across the flats, because that is the best way for light. If the mules are not very long, the driving gear (head stocks) is placed at one end, but if they have

upwards of five hundred spindles in one machine, the driving gear is placed in the centre. By having the head-stock placed in the centre, between the two ends, there is less strain thrown upon the rollers that are nearest the driving gear. In short, this plan of placing the driving gear in the centre divides the strain between all the driving parts—such as wheels, pinions, bands, &c.

The shaft that drives the mules extends from one end of the spinning flat to the other. For each pair of mules there is a small cross shaft, with the pulley on it that gives motion to the mules, so when calculating to find the speeds of the different parts of the machine, it is begun at this driving pulley, having previously ascertained the speed of the cross shaft. The speeds of the different parts are traced out in the same manner as in some of the other machines that have already been taken notice of. The spindles in the mule can be driven at a greater number of revolutions per minute than what can be done with the spindles of the throstle, and, like the throstle, the speed of the spindles determines the speed of all the other parts of the mule, whatever they may be. It is not uncommon to drive the mule spindles at seven thousand revolutions per minute, although some spinners consider that a less speed, is more profitable. The draught given to the rollers in the mule is done in the same way as in the throstle—that is, by giving

a greater speed to the circumference of the front roller than what is given to the circumference of the back one; but there is a little difference in the mode of finding the number of twists per inch, that are given to the yarn. With the throstle frame we have only to ascertain the speed of the front rollers, and find the number of inches of yarn they will deliver in one minute, and then divide the revolutions of the spindles by the inches of yarn, and the answer is the number of twists per inch. This would hold true with the mule also, but it is not so easily ascertained; and the way it is done is, to find the number of inches of yarn the rollers will deliver in the time that the carriage makes one draw—that is, from the instant that the carriage begins to recede from the rollers, until it is full out, and then to find the number of revolutions the spindles have made, from the time the carriage began to move from the rollers, until the spindles have stopped for the purpose of winding the yarn on them.

The carriages in some mules traverse only fifty-six inches, and in others the traverse is as much as sixty-six inches; but suppose, for example, that it is sixty inches, and that there is no gain in the carriage, that would be sixty inches of yarn, and that the whole quantity of revolutions the spindles have made, to be ten hundred and twenty, then 1020 divided by 60 will give the twists per inch.

EXAMPLE No. 18.

```
60)1020(17 twists per inch
   60
   ---
   420
   420
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What is meant by "gain" in the carriage, is the extra speed it travels at, compared to the speed of the front rollers; if the front rollers put out fifty-nine inches of yarn, in the time that the carriage traverses sixty inches, that will be one inch more, and that is called one inch of gain. For some of the finer numbers of yarn the gain may be three, four, or five inches; it is only when spinning very low numbers that the carriage has no gain, but. for the finer kinds of yarn, besides the gain in the carriage, there is a certain amount of stretching after the rollers have stopped giving out; so that it is the actual number of inches of yarn that is produced in one draw, that is taken to divide by (as the divisor), and the whole number of revolutions of the spindles that are to be divided—that is, the number of revolutions that are made, after the carriage is full out, is to be added to the number of revolutions the spindles make during the draw, and that will show the real number of twists for one inch of yarn, if the spindles are not stopped by the spinner, which is sometimes done before the full compliment of twist is given to the yarn.

the spinner is standing ready, waiting until the draw is finished for the purpose of putting the carriage in again, if he takes hold of the wheel before it stops, the twist is reduced, and, although the spinning master may have made out all his calculations quite correctly, and have made the change accordingly, yet when the yarn is brought into the wareroom and tested, it is found wanting in twist. This is looked upon as a very great fault, because it is not very easy to detect it, for, if the worker is dishonest, he may keep the twist all right for some time before the set of cops is finished.

The spinning mules are named in the trade "hand mules" and "self-acting mules." In the olden times of mule spinning, what was understood to be hand mules, were those which were worked by the spinner without the aid of steam, water, or animal power; but, at the present time, what is understood as a hand mule, is one that is wholly propelled by mechanical power, excepting the putting in of the carriage, and working the guide for the building of the cops, which are done by the spinner. Where the mules are large, the spinner is assisted by the power in putting in the carriage: all he has to do is merely to guide it, and build the yarn on the spindles. What is named the "self-acting mule" is wholly propelled by the steam engine, or water wheel, or whatever is the motive power; it does not require the spinner to put in the

carriage, or build the yarn on the spindles; in fact, there is no spinner required, all the different movements being performed by machinery, the workers keeping the machine supplied with rove, and "piecing" the ends.

When the self-acting mules were being introduced into the trade, some very important alterations were made in hand mule spinning. The spinner's "price list" at that time was in a graduated scale. For mules with twenty-one rollers in length, and all below that number, a certain price was paid for a given quantity, and the price for the same quantity was reduced as the mules were increased in length, up to eighty-one rollers; at that size of mules, and all larger, the price remained the same. The difference between the prices paid for the twenty-one rollers, and that paid for the eighty-one, was equal to thirty-five per cent., which was a great inducement for the employers to put in long mules. Any new mills that were put up were made wide enough to hold the long mules across the flats, but those employers that had the old narrow buildings, put them in the long way of the flat. As most of the old mules had the head-stock at the one end, two of them were taken and coupled with the head-stock (driving gear) in the centre. This was one way of getting the advantage of the low price list. Another plan was, to keep the short mules standing across the flat in the narrow mill, and causing one

spinner to work three pairs. This was done by having the driving gear of the three mules connected in such a manner that, whatever movement was made by the spinner on one, was transmitted to the other two, so that the six mules, or three pairs, were worked by the one spinner, the same as if they were just one pair. This lengthening and coupling of the hand mules was the means of reducing the price of spinning very much, and that reduction in the cost of spinning helped to retard the introduction of the self-acting mules for some time; but, by degrees, the hand mules were, to a great extent, superseded by the self-actors for all the low numbers.

The hand mules that are in the trade at present, are mostly used for spinning fine numbers, and it is a question not yet decided, whether the self-actor or hand mule will be the most profitable, even supposing that improvements were made, that would enable the self-actors to spin the very finest numbers. There is more to be taken into consideration, in calculating what might be the most profitable machine, than the mere wages paid to the piecers that attend to the self-actors, and the wages paid to the spinners and piecers of the hand mules. The hand mule spinner of fine numbers, besides putting in and guiding the carriage, attends to the piecing of a number of ends, and sees that the workers under him do their duty properly. He is responsible for all the work done at the pair of

mules which he works. The spinning master can superintend more hand mules, than what he can do, when they are self-actors.

The first cost of a self-actor is greater than the hand mule, supposing them both to have the same number of spindles, and the self-actor requires more power to drive it, and also more oil to keep it lubricated. The repairs required for the wear and tear, and breakages, in the head-stocks, are a great deal more in the self-actor than in the hand mule. All these things should be taken into calculation in estimating the probable profits that could be made from the two different machines. Notwithstanding these drawbacks in the self-actors for fine numbers, the invention of them has been of great utility to the trade, and the men employed at the mules. The working of a pair of hand mules, when spinning coarse numbers, was a very laborious job for the spinner. Besides the labour of putting in the carriage, he has to turn the wheel with one hand, and, with the other, work the guide that builds the yarn upon the spindles in the form of cops. When the numbers are very low, the production in both pounds and hanks is much increased, and, in proportion to the number of hanks produced, is the distance the spinner has to travel. Any number below eighteens causes the spinner to walk many miles every working day. He has scarcely got the one carriage put in before the

other one is out waiting upon him to put it in again; so that he is kept walking at a smart pace the whole of the working hours, except when he is "slipping," or doing other little repairs that may be required.

The self-acting mule is a very complete machine. A number of the mechanisms that are attached to it are of wonderful perfection, and the time and talent spent to bring them to the state they are in at present must have been immense. Some of the movements those mechanisms have to perform are of the most intricate kind. When the carriage of the mule has got full out, and ready to be backed in, the yarn has to be uncoiled from the points of the spindles, and then it has to be wound upon them, beginning at first with the bare spindles, and putting on one layer of yarn after another, until the yarn is made into the form of a cone; so that the speed of the spindles is different every time the carriage is put in, until the cone shape is made. After that, the winding is more regular; but still, the rotation of the spindles has to be regulated to suit all the different diameters of the cone. These things were done in the hand mule by the spinner. When the mechanism was found out to perform them, the great difficulty of having a self-actor was overcome; for the putting in of the carriage was, as compared with these movements, a simple thing.

The apparatus for shifting the belt, from the tight pulley to the loose one, is similar to what it is in the

hand mule; but, when the belt in the self-actor is shifted from the pulley that brings the carriage out, it puts in motion the different parts that have to put the carriage in: "strip" the spindles, and put the yarn upon them. In short, all the different things that the spinner did in the hand mule, are performed by machinery in the self-actor, except piecing the ends.

CHAPTER VI.

THREAD MAKING.

At pages 108 to 113 in the third chapter, some remarks are made concerning thread making. To explain the meaning of the word "thread," so that it will not be misunderstood for a thread of yarn, as it frequently is, by saying "so many threads in a web," "threads out," &c.; (meaning that there are threads awanting in the cloth, which in weavers' phrase is, "ends out.") What constitutes thread is the particular way it is twisted, and it may be made from yarn spun from very different materials, such as cotton, flax, silk, worsted, jute or hemp. But the materials that are most in use, from which the yarn is spun for thread making purposes, are cotton, flax and silk. Cotton yarn is in great demand at present for making thread, and has been so for some years; the demand for sewing

thread made of cotton yarn is attributable to the large quantity of it being used by the sewing machines. The number of these machines, which are made every year, both in this country and America, is immense, and is still increasing. Since the sewing machines have become so common, the sewing put upon dresses is much greater than what it was before their introduction, which is causing a great consumption of thread.

The business of thread making is now a very important one; there is a large amount of capital sunk in it, and some of the establishments where it is carried on are very extensive; and, like the other concerns where manufacturing or making of anything is carried on extensively, division of labour has been introduced. It was not uncommon at one time, for the thread maker to spin the yarn that he required in his business, and also to make all the bobbins requisite for the thread he made; but now, many of the thread manufacturers buy the yarn that they require from the cotton spinners, and the small bobbins that the thread is wound upon when it is finished are bought from the bobbin makers. These bobbin makers are located in different parts of the country, where wood, suitable for the purpose of making bobbins, can be got cheap; and there is a great number of bobbin blocks imported from America. These blocks are made different sizes, to suit the dif-

ferent kinds of bobbins, the bobbins, in many instances being finished by the thread makers.

A number of factories where the making of thread is carried on, are not very suitable for the purpose, because, when the buildings were erected, they were not intended to be wholly occupied by thread making machinery, and the consequence is, the business cannot be made so profitable as when the buildings are put up to suit the different divisions of work. It is the same with thread making as it is with spinning; in both, it is of the utmost importance, that all the different machines should be so arranged in the factory, that they may be worked without unnecessary loss of time.

If the factory is put up specially for the thread business, then all the places for the various departments can be arranged in the most suitable manner. We will suppose that there is no spinning to be carried on along with the thread making, and that the proprietor buys his yarn, either from the spinner direct, or from the yarn merchant. In either case, a place for storing the yarn when it is delivered will be required, and this place, into which the yarn is put, should be near to the department that commences the operation. In the first department there is the winding machines, and if the place is sufficiently large there may be other machines; however, the winding machine is the first that receives the single yarn.

WINDING MACHINE.

Originally when only one end was wound upon the bobbin, the machine for doing it was of very simple construction. It consisted of one tin cylinder, which extended from one end of the frame to the other, and this drove a range of upright spindles. A small shaft with a heart fixed upon it, caused a wood rail to traverse up and down for building the yarn on the bobbins. In this wooden rail there was, for each bobbin in the frame, a piece of wire, hooked at one end and screwed at the other, and this wire guided the yarn on to the bobbin; some of these machines were made what is called double, that is there were two ranges of spindles, and they were driven by the one cylinder, also the heart shaft did for both ranges.

When adjusting the traverse rails, for building the yarn on the bobbins, the workman turns the heart shaft round, until the small pulley that is in contact with the heart rests in the hollow of it. He then sets the wooden rails with the wires in them, the one up at the top of the bobbin on one side of the frame, and the other down at the bottom of the bobbin at the other side of the frame. When this is done, he fixes the rod that connects the heart lever, with one of the traverse arms. Having got the traverse rails properly set, he adjusts the ends for each bobbin separately, by the hooked wire, which is done by screwing them

either out a little, or a little further in, according to how the yarn is being built upon the bobbin. The cops that are to be wound are placed on skewers that may be made either of wood or iron, and these skewers are fixed perpendicularly in a wooden rail. The yarn, as it is unwound from the cops, passes up over a wire, then down under another hooked wire, then over a roller, and down under the guide wire on to the bobbin. The roller that the yarn passes over, is in general covered with woollen cloth, which acts as a brush on the yarn, taking off any loose substance that may be adhering to it. There is also a piece of sheet iron with a slit in it, attached to the winding machine, and the yarn is made to pass through this slit, for the purpose of catching any bad piecings or lumps that may be on the yarn. The speed of the spindles for the common winding machine, is different in different factories; very often the speed is regulated according to the ability of the worker, or the number of bobbins the winder has to attend to.

In winding from the cop, when it is placed in a perpendicular position, the winding may proceed at a great speed, until the cop is nearly all unwound from the skewer, but the ends frequently break when there is a little yarn left on the skewers; this left yarn is called "bottoms," and to keep these bottoms from being made into waste, the skewers are put in a horizontal position, for the purpose of getting the

bottoms wound. As the winding of the bottoms cannot be done at a speed so high as when the cops are standing perpendicular, there are a few spindles for the purpose, and these spindles have larger wharves on them, which gives the spindles a slower motion. The winder has a number of extra skewers, to save the time that would be required in shifting the bottoms from one skewer to another.

When the winding of the yarn is done by the common winding machine, whatever may be the number of plies that the thread is to be composed of, a bobbin for each ply is put into the twisting frame. Suppose it is three ply, then there will be three of the winders' bobbins put up for each bobbin in the twisting machine. At one time this was almost the universal plan, but now it is almost superseded by the winding machine that doubles the yarn at the same time that it is winding it.

One of these doubling winding machines is very similar in construction to the common one, but has the apparatus added to it that makes it suitable for doubling. For illustration, we will suppose that three ends are to be wound on a single bobbin; of course, three cops will require to be put in the creel in place of one, the ends are taken over and under the wires in the same way as in the common machine, but besides that, each end has a separate lever that it passes under, and this lever is so delicately balanced,

that the end is sufficiently strong to keep it from falling down. If any one of these ends is awanting by the cop running done, or it being broken, or whatever may be the cause, the end of the lever that is held up by the yarn passing under it, falls down, and the other end is raised, by which action the bobbin is stopped, until the winder replaces the end that is awanting. By this mode of winding and doubling at the same time, it prevents any "singles" from passing on to the bobbin. Although I have taken only three ends for illustration, there may be four, five, or even six ends doubled, and wound on the one bobbin.

These winding machines are generally made with four levers, which means that either two, three, or four ends can be wound upon the bobbin as may be required at the time being.

The yarn is not always doubled direct from the cop. It is preferred in some factories, to wind all the yarn single on to the bobbins in the first instance, and then take these bobbins with the single yarn, to the doubling winding machine, where they are placed in the creel according to the number of plies that are to be doubled. What is considered to be the advantage gained, by winding the single yarn first on to bobbins before being doubled, is, there are fewer breakages, in consequence of the bobbin being capable of holding as much yarn as there will be in three or

four cops, which causes them to run a longer time in proportion.

A few years since, an improvement was made on the thin plate of iron with the slits that the yarn passes through, and it was this: By having the one slit, as formerly, for each end, it was easy for the winder to lift the end out of the slit, when it was stopped by a bad piecing, or any other obstruction, and allow it to pass with the faults. But by this improvement it is more trouble for the winder to take the end out of the slit, than it is to break it and knot anew. The slit in the iron plate is made like an arrow, with a slit on each side of the main slit, so that if the winder attempts to lift the end up, it goes in either to the one or the other, and the winder is obliged to break the end, take out the bad bit, and knot it anew.

There is another bobbin winding machine, of a very different description. For making good work it is better than the one just noticed, but the first cost of it is much higher, and it occupies more space than the other, for the same number of bobbins. This machine has no cylinder nor spindles, and of course no banding is required for driving the spindles. It has one shaft the whole length of the frame; on this shaft there is a small drum for each bobbin. In some of the machines, that are called double winding machines, one drum is made to drive two bobbins.

This is accomplished by having the drums larger in diameter than what they are in the single machine (about ten inches in diameter) and placed along the top of the machine, in the centre between the two sides; and the bobbins are driven, not on the exact top of the drums, but on each side, a little from the top. The drums are made to fit the size of the bobbin between its ends. These machines have one advantage over the spindle kind, and that is, the yarn runs at a uniform speed, from the time the bobbin begins to fill, until the full quantity is wound on it; whereas, in the spindle machine, the speed of the yarn increases as the bobbin fills. So it is very difficult to get the full production out of the spindle machine, because, if a speed is fixed upon, that will be the right one when the bobbin is empty, it will be far too great before the bobbin is half full. Therefore, the speed of the spindles must be confined to such a rate that the velocity of the yarn will not be too great when the bobbin is full. The barrel of the bobbin is about four inches in circumference, and when it is full of yarn, it will be at least ten inches. From that it follows, that the speed of the yarn at the beginning is two and a half times too slow.

To make a distinction of the winding machines, we will name the one that has no spindles, the "drum winding machine," and the other the "spindle winding machine." The drum winding machine can

be employed to wind either from cop, bobbin or hank. The bobbin is kept in its place at the top of the drum by a small arbour that goes through it. The points of the arbour project beyond the bobbin ends about three quarters of an inch, and the extreme ends of the arbour enter the slits which guide the bobbins, as the winding proceeds. As the diameter of the bobbin increases, the arbour rises in the slits, the bobbin being driven from its circumference by the drum, it is evident that the yarn will always run at the same speed. It is the friction caused by the bobbin pressing on the drum that makes the bobbin revolve.

When the drum machine is employed for doubling the yarn, a different arrangement has to be made with the small levers that stop the bobbin when an end is awanting, from the way they are applied in the spindle machine. In the drum machine the bobbin is lifted up just as much as take it out of contact with the drum, and this is done by a double ended lever acting upon the parts of the arbour that are between the ends of the bobbin, and the slit that guides the arbour.

If it is hank yarn that is to be wound, swifts are required to put the hank yarn on; and as it is not practicable to wind the yarn from hank, as fast as what it can be done from the cop, or from the throstle bobbin, the machine has to be driven at a slower rate, which is done by changing the driving pulleys to a

pair larger in diameter. The exact speed will depend in a great measure upon the kind and quality of the yarn. It has been found in practice, that it is not profitable to wind from hank and double the ends at the same time; therefore, hank yarn is always wound single for thread making purposes and afterwards doubled.

There is a large quantity of sewing thread made of coloured yarns, and, until lately, all this yarn was dyed in hanks, (notice will be taken of the new process further on). Thread is made in all the different colours, suitable for the fabrics the thread is to be used on, and the best is made of yarns that are dyed before being made into thread; because, if the yarn is twisted in the gray state, and made into thread before it is dyed, the colouring matter is prevented from getting into the fibres of the yarn, and, after being worn for a time, the white fibres of the yarn appear in the thread. Therefore, if really good coloured thread is to be made, the yarn should be dyed first, and then twisted; but this is seldom done.

If the manufacturer buys his yarn in cops, for making the coloured thread, then the first thing that is done, is to make the yarn on the cops into hanks, and that is done by the reeler. The reel for cotton is the common fifty-four inch one, but it does not matter what kind of reel is used, as far as the dyeing of the yarn is concerned; all that is required is to get

the yarn made into hanks, for the purpose of being dyed. The reeler is generally paid by the weight of the yarn, according to the fineness of it, so many lbs. for a shilling; the finer it is, the number of lbs. is less that is given for one shilling; so, in the case of reeling, merely for dyeing purposes, there is no necessity for counting the number of hanks, seeing that both the reeler and dyer is paid by the weight; however, it is better to count the hanks in the usual way, and collect them into bunches of ten lbs. each, as the *winder* may be paid by the spyndle.

When the hank yarn is brought from the dyer, it is given to be wound on to bobbins, at the hank winding machine, which is the drum winding machine without the apparatus for stopping the bobbin when an end breaks. After it is wound in the single state, the bobbins are taken to the doubling winding machine, and from that to the first twisting frame. What is meant by the first twisting frame, is the one that gives the twist to the single yarn. If there are three plies of single yarn put upon the bobbin at the doubling machine, the three plies are twisted by the first frame, the reverse way from the twist the yarn received at the spinning machine. And, suppose the thread that is to be made, is to have nine plies of single yarn in it, three of the ends with the three plies of single yarn in them are twisted together, which makes up the nine plies. This is done at the second

twisting frame, and the twist given to the thread at this frame, is the reverse of what is given at the first, which is the same way as the single yarn.

We will endeavour to make this, about the twist given to the thread, a little plainer.

Standing in front of a throstle or mule spinning machine, and looking toward the spindles, we see that the spindles revolve from the right to the left hand; this is the usual way that all yarns receive their twist at the spinning machine, although it is not the universal way, as some yarns are twisted by the spindles revolving in the contrary direction. But suppose the yarn is spun in the usual way, the spindles of the first twisting frame revolve in a contrary direction from the spindles of the spinning machine; that is, they revolve from the left hand to the right, so that the three plies of the single yarn receive their twist at the first frame, in a contrary direction from the way it was spun. The second twisting, which in general gives the finishing twist to the thread, is done at the second twisting frame, the spindles of which revolve the same way as the spindles of the spinning ne, thus reversing the twist on the thread, from which it received at the first twisting frame.

spindles in the spinning machines, and the twisting frames, were all made to revolve in the same direction, the thread would not be properly made; it would have a great tendency to curl up into "snarls,"

and it would be difficult to keep the thread smooth; hence the reason for reversing the twist each time that it is taken from one frame to another. Suppose that the thread is to be made with eighteen plies of single yarn, and that the first "cord" had two plies which would be twisted at the first frame; and that three of these two plies were twisted at the second frame, this would make six plies in one cord; and that three of these six ply "cords" were twisted together to make the eighteen ply. This would be a third time it was twisted, and this third twisting would require to be done at the first twisting frame, so as to give it the reverse twist from what it received at the second.

TWISTING FRAMES.

Although the machine, which is similar to the throstle frame, is used for twisting thread, there are other machines used for twisting; but the one like the throstle is almost always applied for making thread. Like the common throstle for spinning yarn, the[illegible] used for making thread have been greatly improved also. The pitch of the spindles is larger in some of the twisting frames than what it is in the common throstle, consequently, fewer spindles can be got in the same space; and in these frames the spindles are made heavier also, and have larger wharves. But, in

those that are made with the small pitch and common spindles, there is no difference, as far as the spindles, the cylinder, and driving gear, are concerned, from the common throstle; however, the flyer in the twisting frame has got no top eye, it has just the two legs, and the point of the spindle projects a little through the body of the flyer. In place of the eye, there is for each spindle a small glass or delf tube, right above the centre of the top of the spindle, for guiding the thread down to the flyer. This guide keeps the thread from being thrown out by the centrifugal force it receives from the flyer. The worker, when mending a thread, gets it put into this guide by small slit that is made in the side of it for that purpose. In old frames there were, instead of glass or delf guides, iron wire es, but they were found not to last so well, being ve liable to be cut with the thread.

The rollers that are used in the twisting frame, for regulating the twist that is to be put upon the thread, are also different from them in the throstle spinning frame. Those that are most approved of have one top roller for each thread, and the under ones are all coupled together in one range, in a similar way to the front rollers of the throstle, but both the top and under rollers are made larger in diameter, so that they may have a better hold of the thread; and, to prevent them from getting rusted, they are all covered with

sheet brass. The advantage gained by having only one top roller for each thread is, that when the thread requires to be mended, or put up anew, the worker can do it with much less trouble, and in a shorter time, than it was possible to do on the old plan.

The bobbins with the yarn on them that is to be twisted, are put in the creel which is at the back of the rollers, and the thread is taken down below the under roller, then up and through between the under roller and the top one, then over the top one, and down to the flyer, and the thread is then fixed to the bobbin that is on the spindle. When this is done all over the twisting machine, it is ready for the pinion to be put on, that will give the required twist to the thread. In the best twisting frames there is a twist pinion for each side of the frame, so that, if required, two qualities of thread may be made in the one machine at the same time. The spindles are always driven at the same speed, and the quantity of twist that is put upon the thread is regulated by the rollers; the slower the rollers are driven the greater will be the number of twists per inch put upon the thread. The number of revolutions the spindles will make in one minute, is found in the same way as has been shown for finding the speed of the spindles in the throstle frame. For the ordinary size of frames (that is, the frames that take in the ordinary size of bobbins), a very good speed for the spindles will be four thousand

three hundred revolutions per minute. When the speed of the spindles is known, and the twist that the thread is to receive per inch, and, dividing the speed of the spindles by the number of twists per inch, the speed that the rollers should go at will be found. If the twists per inch be eighteen, and the revolutions of the spindles per minute be four thousand three hundred, divide the four thousand three hundred by eighteen.

EXAMPLE No. 1.

```
Twists per inch, 18)4300(238·88 number of inches of thread.
                    36
                    --
                     70
                     54

                     160
                     144
                     ---
                      160
                      144

                       160
                       144
                       ---
                        16
```

This shows that, in one minute, there can be 238·88 inches of thread produced, and a speed must be given to the rollers, so as that length will be given out, in the same time that the spindles take to make 4300 revolutions. If the circumference of the rollers be four inches and three-quarters, by dividing the

number of inches of thread that are produced per minute, by the circumference of the roller, the answer will be the number of revolutions the roller should make in one minute.

EXAMPLE No. 2.

```
Circumference of roller, 4·75)238·88(50·2905
                               2375
                                 1380
                                  950
                                  4300
                                  4275
                                    2500
                                    2375
                                    ----
                                     125
```

From this example it is shown that the rollers should make fully fifty revolutions per minute, when the twist given to the thread is eighteen per inch. The number of teeth that should be in the pinion will be found in the same way as is given for the throstle, and, when once it is known what pinion will be required for a given number of twists per inch, it can be taken as a data, and, by simple proportion, the pinion for any other number of twists will be found.

The number of twists to be given to an inch of sewing thread, will altogether depend upon what kind of thread is to be made. The finer kinds will require more than the coarser. The Twist Tables

given in chapter V. for common yarns, will be found useful as a criterion for finding the proper number of twists per inch for thread also, by taking the size of thread as yarn; and, as there are six different tables, any one of them that is found most suitable, can be chosen for guidance in changing from one size of thread to another.

The apparatus for working the bobbin rail, for the purpose of building the yarn upon the bobbins, is the same as in the throstle spinning frame. On the front edge of the traverse rail is fixed a piece of sheet iron serrated from one end to the other. When making the heavier kinds of thread, a considerable amount of drag requires to be put on the bobbin, so as to keep the thread to the proper tension; this is accomplished as follows:—The bottom of the bobbin has a groove turned out on it, and a small piece of banding is attached to the back of the traverse rail, and brought forward to the serrated piece of iron at the front. This piece of banding is made to go into the groove that is in the bobbin bottom, a small weight is hung to the end of the banding, and the drag is regulated by shifting the banding from one serrature to another; by shifting the band and the weight towards the bobbin the drag is increased, because the band encircles a larger part of the circumference of the bottom of the bobbin. If a sufficient pressure cannot be put on the bobbin with the small weight for the

coarsest thread, it is taken off and a larger one put on.

For very light thread, but more especially for the twisting of the common yarns, for the cords that are to make the thread, the ring throstle is by some employed. The reason for using the ring throstle, in preference to the other, is, that it can be driven at a much higher speed; but the way that the twist is given in this machine, prevents it from making so good a quality; therefore, it is not much used for giving the finishing twist to the thread. It is better adapted for twisting two ends of common yarn together, preparing it for the other frames that give the thread the last and finishing twist.

Another machine for twisting is the one that is similar in make to the common mule. The spindles and spindle carriage are the same as in the mule, but instead of having three pair of rollers, the same as in the spinning mule, there is only one pair, and sometimes only a single roller in the twisting mule.

The twisting mule is scarcely ever employed for the making of sewing thread, but the yarn twisted with it is largely used for other purposes. There is a large consumption of yarn in making "whip," that is, the yarn twisted together which forms the flowers on lappet cloth.

One kind of whip is made of two plies of single yarn, and another kind is three plies, and a little four

plies. There is a large quantity of whip dyed different colours, but it is almost universally twisted in the gray state, just as the yarn comes from the spinner. The single yarn is wound on bobbins, either on the common winding machine, or at the one where it is doubled; however, it is not so essential to have the yarn wound two or three plies on the bobbins for the mule twister, as it is for the throstle twisting machine.

After the yarn has been put on the bobbins, they are placed in the creel, which is in a similar position to the creel for the rove in the spinning mule. If there is only one roller used, the yarn is put only once round it, which is sufficient to regulate the delivery of the yarn to be twisted. The speed given to the roller is regulated according to the number of twists per inch the yarn is to receive. When any of the ends are broken they are tied when the draw is put in, that is, when the carriage is put close to the roller.

The twisting mules are frequently named "twiners," and those employed for heavy yarns have the spindles larger than those in the common ones, also the spindles have a larger pitch, that is, there is a greater distance between the spindles, which enables them to make larger cops, and that is an advantage to those who buy the doubled yarn, if the cops are not broken in transference from one place to another, which they are more apt to be than the small ones.

The process in thread making that comes after the twisting, (if the thread is made with gray yarns) is in general the reeling. The bobbins that the yarn is built upon at the twisting frame, are taken to the warehouse, and then given to the reeler, for the purpose of getting the thread put into hanks. If the thread is intended to be sold in the bleached state, it is put up into bundles, and sent to the bleacher, or, if it is for coloured thread, then it is sent to the dyer. It sometimes happens that the proprietor has no particular order on hand for any kind, and instead of sending the yarn, either to the bleacher or dyer, it is stored past until an order is got. When that is the case, the yarn is taken to the drying house. In the stove, or drying house, there are ranges of racks, made to suit the length of poles that the thread is hung upon. The hanks of thread are put on the poles, and after they are put into the rack, the thread is spread out for the purpose of being dried. If the thread were stored up in the wet state in which it is when it came from the twisting frame, it would get spoiled by being "mill dewed" or rotted; mill dew is just the first stage to rottenness; therefore, it is requisite to have it properly dry before being bundled.

There are many different kinds of sewing thread made in the same factory, and if care be not taken to keep each kind separate from the other, the whole work would get into confusion. The system adopted

is, when the common yarn is given out to the winder, the real number of yarn is marked on a ticket and given to the worker along with the yarn; if the real size of the yarn is not put on the ticket, some other mark is put on by which the real size will be known. When the yarn comes from the doubling winding machine, a new ticket is made out, such as two ply 40^s or two ply 50^s; if it is three plies, then it is marked three ply 40^s or three ply 50^s, or whatever number it may happen to be. There is also another ticket given when it is taken to the second twisting frame. When this is taken from the finishing twisting, to be reeled into hanks, the reeler puts a distinguishing mark on the cords she leases the hanks with. This is done by putting knots upon the end of the cords, one knot represents a certain kind, two knots is for another kind, and three knots for another, and so on. The reeler is given instructions to put on the given number of knots, whatever that may be, to represent the kind of. thread. All the particulars and descriptions of the different kinds of thread are entered in a book, and numbered, and these numbers are represented by the "tyes" put in the hanks, so that, if the thread happens to get mixed, the different kinds can be separated, and put right according to their kinds.

POLISHING THE THREAD.

What is meant by polishing the thread is a certain process of dressing it is put through, to give it a gloss, and make it look smooth. Although it does not improve the quality of the thread, as far as utility is concerned, it gives it a very much better appearance, and that makes the thread sell better. There has been a great amount of attention paid to the process of polishing sewing thread of late, both in regard to the machinery used for doing it, and the stuff put into it.

An older method of polishing thread was, to put the hanks on a pair of horizontal revolving rollers, which caused the thread to move round. There was a circular brush placed in the box that held the liquid substance that was put upon the thread. The under side of the brush came in contact with the stuff that was to be put on the thread, and as the thread moved in a contrary direction from the brush, and being in contact with it, the thread was dressed. When the thread had received the requisite quantity of dressing, it was taken from the pair of rollers, to another pair, which made the thread revolve in a perpendicular position. In front of the hanks of thread there was a pair of brushes—one of them brushed the thread until it was nearly dry, and the other was for cleaning the one that was kept

brushing the thread; this brushing put the polish on the thread.

Another way of polishing is the following:—When the thread has been returned from the bleacher, or dyer, in hank, it is again taken to the drum winding machine, to be wound from the hank on to large bobbins. These bobbins are next taken to the polishing machine. The machine consists of two cast-iron sides, on which are fixed the plumer-blocks for the different working parts. There is first the main shaft of the machine for driving the feed rollers, the brushes, the fans, and the bobbins. At the end of the machine, where the finishing rollers are, the bank for putting the bobbins in is placed. The bank may be made in the form of the letter V, or it may be made like the common ones, which are made forming part of a circle; but the V bank is preferable for this purpose. The two sides of the bank are set as far apart from each other as will give room for the worker to get between them, for the purpose of banking, that is, putting the bobbins on to iron wires, and placing them and the bobbins in the bank.

When the requisite number of bobbins are put in the bank, the worker draws all the threads through a reed, putting only one thread in each split of the reed; this operation is performed with an assistant, the assistant taking each thread in rotation, and handing it to the reeder. The person who puts the threads in

the reed does not begin at the end of the reed, but in the centre of it, and puts all that is in one side of the bank in one half, and all that is in the other side in the other half of the reed. The reed is hung to the box immediately behind the rollers; the use of it is, to keep each thread separate from another.

The feeding rollers are made of cast iron, with a malleable iron shaft in the centre, projecting at each end, on which the journals are formed. The top roller is made heavy, about two hundred-weight. Both rollers should be covered with sheet copper, and the copper covered with woollen cloth. The box for holding the dressing is fitted right below the under roller, and is made so as the under side of the bottom roller will be within an inch of the bottom of the box. The under roller is driven with wheel and pinion, and the top one is driven by friction, as it rests on the top of the under one. The thread is made to pass through between the rollers, and as they revolve, the woollen cloth that they are covered with gets saturated with the dressing, which is pressed into the thread when in the act of passing through between the rollers. There is always a sufficient quantity of dressing kept in the box, so as to insure that the under roller will revolve in it. The speed of the rollers can be changed by a pinion, to suit the dressing of the thread. For heavy thread, the roller will require to move more slowly, than for the lighter kind.

The stuffs which are used for dressing thread are various; the most common are made from wheat and sago flour, although other substances have been used, and some of them with very good results, as far as the polish given to the thread was concerned; but the expense of the articles prevented them from being continued. When wheat flour is used for the dressing, the flour should be sour, and it should be steeped in clean water a few days before being boiled. The length of time for steeping will depend upon the weather; but it must remain in the steep until it begins to ferment. After the flour has lain in the steep the proper time, it is stirred up, to mix it well with the water, and before putting it into the boiler it is run through a fine sieve, for the purpose of taking out all the impurities that may be mixed with the flour. After the "steep" (as it is called) is put in the boiler, water is added until the proper proportion is in for the measure of flour, which will depend upon the strength required. When it has been boiled sufficiently, it is put into barrels to be kept until it is required for use. The "dressing" should be allowed to remain in the barrels for at least two or three days before being used.

If sago flour is taken instead of wheat flour, it does not require to be steeped any length of time; when it has been mixed with the water it is put into the boiler and boiled for a short time, and it is used as soon after

it is boiled as possible while it is still hot. There is only a small quantity made at each time, not more than will serve for one day. Some object to the sago in consequence of it being requisite to use it in the hot state, as a large quantity of steam rises from it which keeps the place in a disagreeable dampness.

After the thread has been passed through between the rollers, it is in a moist state with the stuff it has received. The first brush the thread comes in contact with, is for brushing the stuff well into the thread while it is still in the damp state, the other brushes are for putting a gloss on it. The brushes are all of the circular kind, and are driven at a good speed. For the purpose of keeping the air in motion, fans are used; these are placed at intervals inside of the machine. To keep the air from blowing on the first brush and the thread, before it has passed the first brush, there is a lining of wood put across the machine from the one side to the other, and from the floor up to within an inch of the thread. The hold that the brush should take of the thread is regulated by pinching pins; there is a brass or copper rod put along the reed which presses upon the thread, and, by lowering or raising this rod, the depth of brushing is increased or diminished.

By the time the thread has passed from the feeding rollers to the other end of the machine, it should be dry. At this end of the machine are the bobbins that

are to receive the thread after it has been polished. For each single thread there are a spindle and bobbin; these spindles and bobbins are arranged so as to take up as little space as possible; one kind of machine has each row of spindles projecting forward the distance of the diameter of the bobbin from the row next to it. When looking to the front of the place where the spindles and bobbins are, it has the appearance of the seats in a gallery. By having the spindles in this way, the bobbins are got closer together. The spindles in the second row go down behind the bobbins of the first row, and the spindles in the third row come down at the back of the bobbins in the second row, and so on with the others. Each row of spindles has its own guide for conducting the thread on to the bobbins. The spindles are driven at a greater speed than what is merely sufficient to wind the thread on the bobbins, which causes the bobbins to be driven by friction, and this always keeps the thread tight by the drag that is on the bobbins. It is necessary that the threads be sufficiently tight when in the process of being polished.

There is another polishing machine which is a little different from the one just noticed, and is an improvement as regards the mode of preparing the thread for it. After the thread has been twisted and wound on the large bobbins, they are taken to a common warping machine, and as many of them put into the bank as may be required for the polishing machine. The

thread is warped on to a beam in the usual way (the warping machine has already been noticed at pages 107 and 108.) The length that is warped on the beam may be three, four or five thousand yards. After the quantity of thread that is required has been warped, the beam is taken out and sent to the chaining machine, where the whole of the thread is taken off the beam and made into what is styled "a chain." This chain is sent to the bleacher, if the thread is to be sold in the white state; but, if it is to be sold as coloured thread, it is sent to the dyer. When the chain is brought back from the bleacher or dyer, it is taken to the beaming machine, and the beamer winds all the thread on to the beam again. This requires to be very carefully done, more especially if the chain has got any damage done to it by the bleacher or dyer.

After the chain has been put on the beam it is taken to the polishing machine, and placed in stands for it to run in. The stands are at the back of the feeding rollers, in the same position as the bank was in the other machine. The thread is taken through the reed, in between the rollers, dressed and polished in the same manner as was done in the other. Also, the bobbins take on the yarn the same way. It is obvious that, if any of the threads in the chain be slacker than the others, the bobbins, from the way they are driven, will keep them all at the same tension in the process of polishing the thread.

The boiling of the dressing, at the time the thread was passing through it, has been tried in some factories; this was considered to be better for the thread than working with it cold, but whether it is an improvement or not, has not been decided; however, the system has not come to be much adopted, perhaps from the reason I have mentioned before—that is, it creates too much steam in the room where the boiling is carried on.

When the thread has passed through the polishing machine, it is finished as sewing thread, although it is not ready to be sent to the retailers; for, before that is done, the thread has to be put on to small bobbins or "spools," or made up into balls. The small bobbins that it is put on, are of various sizes, to suit the length of thread put on them. At first, when sewing thread was put on bobbins, they were made very differently from what they are at present, both as regards the machinery that makes them, and the form of the bobbin itself; when they were introduced, the barrel or body of the bobbin was not the fourth of the size of what they are now made, at least the great majority of them. There are still a few of the bobbins made with the small barrels. The thick bobbins, I believe, were introduced to give a deceptive appearance. It is evident, that the large bobbins will cost more than the small ones, which is a loss to all concerned. Respectable makers mark the length in

yards, on the end of the bobbin, and the buyer is guaranteed that the number of yards marked is the length of thread on the bobbin.

A system has been adopted, at least by one thread manufacturer, to prevent any tampering with the tickets on the ends of the bobbins, after they have been sent out of the factory; at all events, the tampering can be detected by the consumer. The system is this:—The empty bobbins are taken in a basket to a room, where there is a number of children, who take a single bobbin from the basket, and put a ticket on the barrel of the empty bobbin. On this ticket is the maker's name; also the number of yards that should be on the bobbin. The tickets are previously gummed to make them adhere to the bobbin. The bobbins, when ticketed, are arranged in tin trays—a given number for each tray—and these are taken to the "spooler." The parties who buy the thread will see, after the thread on the bobbin has been used, if the outside ticket has been altered, by comparing it with the one that was fixed to the barrel of the bobbin.

The small bobbins used in the spooling machines for putting the thread on, were, at one time, all made in the common turning lathe; the turners were principally boys. The wood for the bobbins were cut up, with a circular saw, into small blocks suitable for the size of the bobbins. At that time small wood was in great demand for thread bobbins, but now,

trees from six to twelve inches in diameter are taken for making these bobbins, and are preferred to the smaller trees.

The machines used in connection with the making of the thread bobbins, are—the blocking machine, the turning machine, the bobbin polishing machine, and the saw for cross-cutting the trees in lengths suitable for the lengths of the blocks that the bobbins are to be made from. These pieces of wood are taken to what is called the blocking machine, which is similar to the common drilling machine. There is put, into the spindle of the blocking machine, a common boring bit, for boring the hole in the centre of the block; there is also a cutter, set as far off the centre as will give the proper diameter to the block. The boring bit is made to enter the wood, and bore about half an inch deep, before the cutter begins to cut out the piece of wood that is to form the block. The workman cuts as many blocks out of the piece of wood as he can manage to get; the refuse is used as firewood.

In the blocking machine, the pieces of wood, from which the bobbins are to be made, are bored and made circular, ready for the turning machine, which consists of a pair of common turning lathe heads and a double slide rest. The block of wood is put on to an arbour, which is in the running head; and on to the slide rest are fixed the chisels, which cut the

block into the bobbin. The workman moves the chisels with a lever. The one movement cuts out the centre of the bobbin, and the other cuts it to the proper length. The chisel that takes out the centre part is placed on the rest in front of the bobbin, and those for the ends are at the back of it. The turning of the block of wood into a bobbin does not occupy more than a quarter of a minute.

After the bobbins are made, they are put into a barrel or wooden cylinder, to receive a certain amount of polishing. The cylinder or barrel is hung on journals.

There is an opening in the side of the cylinder through which are put the bobbins and the stuff with which they are to rub; when the quantity is put in, the opening is closed, and the cylinder is made to revolve slowly for a number of hours. As the cylinder revolves, the bobbins, wood turnings and any other stuff that is put in, keep falling from the rising side of the cylinder to the lower part of it, this movement causing them to rub against each other; and this rubbing puts on the polish. But those bobbins that are to get a better polish than this system can give, are put into a turning lathe, and boys polish them with paint and oil.

SPOOLING MACHINES.

The machines that are used for winding the thread on to the small bobbins, which are sold to the retailers, are called "spooling machines." The kind that winds only a single bobbin at a time is the original one. It is a very neat little machine, consisting of a spindle lying horizontally for the small bobbins to be put on, and underneath this spindle are other two spindles with screws cut on them. The one has a left-handed screw, and the other a right. These two screwed spindles work the guide for the thread while the other spindle is winding it on to the bobbin. The spooler keeps her hand upon the guide, giving it a gentle pressure towards the bobbin, and the part of the guide that comes into contact with the screw is changed from the one screwed spindle to the other, each time the thread guide comes to the end of the bobbin; thus a constant traverse of the guide is kept up until the bobbin is filled with thread. There is also an upright spindle upon which the large bobbin is put—that is, the large bobbin with the finished thread on it, that was brought from the polishing machine. Originally these spooling machines were driven by the worker's foot, but now they are mostly driven by the motive power that propels the other machinery that is in the factory.

The workers that put the thread on to the small bobbins are girls from fifteen years upwards; they are called "spoolers." Their work is light, but they have to be cleanly and careful, not allowing any lumps or knots to pass, more especially if the thread is intended to be used in the sewing machine. When there is no index on the machine to indicate the length of thread put on the bobbins, she runs as much on as fills the bobbin flush with its ends; when the bobbin is full, she inserts the thread into a slit on the end of the bobbin, and then cuts the thread, takes the full bobbin off the spindle, and puts an empty one on. The time taken to fill a bobbin is wonderfully short, but, short as it is, ingenuity has been exercised in trying to supersede these machines by others more complicated. These latter, however, although fitted for large orders, are not likely to supersede those used at present, which are better for small ones.

The other spooling machine that we will take notice of is one that can fill a number of bobbins at once, the number being only limited by the length of the machine. A machine to be attended to by only one worker, twelve or fourteen bobbins may be a sufficient number for her to manage. This machine is very complicated, yet very complete in all its movements. The spindles for the small bobbins to go on lie horizontal; there is a place opposite each spindle for the empty bobbin to be put, to lie there ready to

be pushed on to the spindle, whenever the full one is jerked off.

The different movements in this machine perform the following things:—It puts the empty bobbins on the spindles, fills them with thread, cuts the slit in the end of the bobbin, puts the thread into the slit, cuts the thread, and takes off the full bobbin. What the worker has got to do, when she is going to start the machine, is this:—She first puts all the large bobbins on to their skewers or spindles, then puts the small bobbins on their spindles; she next takes hold of the end of the thread that is on the large bobbin, and brings it down to the small bobbin, giving a turn or two round the small bobbin. The machine is then started, and, during the time that is taken to fill the bobbins, she is putting empty bobbins in the places opposite the small bobbin spindles. When the bobbins have got their full quantity of thread, the machine pushes off the full bobbins, and they drop down into a box; as soon as the full bobbin is put off the spindle, the empty one is pushed on, the worker having nothing to do, after the machine is started, but feed it with empty bobbins.

There is an index on the machine, which can be set to regulate the number of yards that is to be put on the bobbins. When the number of yards has been put on the bobbins, the index stops the spindles, and puts in gear the apparatus that changes the bobbins,

and makes the requisite movements for the different shifts. There is a cam wheel connected with this apparatus, which is the principal actor for most of the movements, and, after it has done its part, it puts the spindles in motion for a new filling of the bobbins.

Before noticing the balling machine, I will follow the bobbins a little further. After the small bobbins have been filled at the spooling machine with the finished thread, they are sent in the trays that the spooler received them in, back to the warehouse. There is a ticket attached to the tray, giving the particulars concerning the kind and quality of the thread. These trays with the thread bobbins are sent to the sorting room (each tray contains one, two or three gross); in this room there is a number of benches stretching along and across the flat; at the lower benches there is a number of children, and, opposite each child, is placed one of the trays filled with bobbins as they come from the spooler. The child holds in her left hand a number of the small round tickets that are to be put on the ends of the bobbins (the tickets are previously gummed), and with her right hand she takes a single ticket, wets it with her tongue, and puts it on to the end of the bobbin. It is surprising to a stranger to see how expert the little girls are at putting the tickets on; the gum on the tickets is not' hurtful to the health of the little

workers; the bobbins are not taken out of the tray when the tickets are being put on.

After the bobbins have been ticketed, they are taken to another bench, where the workers are more advanced in years. These workers take the bobbins, and put them up in parcels, with a dozen in each. She has before her the paper cut in slips the size that will exactly do for a dozen; in a twinkling she has a dozen put up neatly in paper, and a string tied round the parcel. Always doing the same thing, they do it so quickly, that it is difficult to observe the different movements of their hands. Other workers get the parcels and pack them in grosses, and they are then returned to the warehouse.

BALLING MACHINE.

Although very little sewing thread is at present put up in balls, yet the machine is used in thread manufactories for other things. When it was the usual way to sell the thread in balls, the wholesale merchant bought his thread by the weight, and the price per lb. was regulated by the cost of the yarn from which the thread was made; when it was made from very fine yarns, the price per lb. was much higher than when it was made from ordinary numbers; it was easier for the merchant to know if he were

getting full value for his money, when the thread was in balls, than when it was in bobbins.

The balling machine consists of a frame in which there are two spindles,—the spindle on which the thread is built to form the ball is in a horizontal position, the other spindle is arranged in the frame in such a manner that it can run in an inclined position, and so that the incline of it can be altered at pleasure, to answer the build of the ball. On the end of this spindle is a flyer, for the purpose of winding the thread round the other spindle; the thread is taken through the neck of the flyer spindle, and up to the end of the leg of the flyer, then through the eye of the leg to the horizontal spindle; both spindles revolve at the same speed, when the ball is being built. If both the spindles were in a horizontal position and set in motion, it is evident that the one ply of thread would be built on the top of the one previously put on; but by the flyer spindle being inclined to the other, and that incline being increased as the thread increases the size of the ball, it builds the balls of that peculiar shape which they have. The worker alters the incline of the flyer spindle to suit the size of the ball that is being made at the time; the balling machine can be driven either by the steam engine or by the worker.

There is a peculiarity connected with the balling machine, which is not in the spooling machine. The

spooling machine runs the thread on the bobbins without altering the twist of it; but, from the way that the balling machine is made, the twist on the thread is altered; every revolution that the flyer spindle makes, one twist will be taken off the thread, or one twist more put on; because the thread, passing through the neck of the flyer, and being wound on the spindle by its leg, the twist is put on in the same manner as in the throstle; the thread being twisted before it comes to the balling machine, if the spindle is driven the reverse way from the spindle in the twisting frame, the twist will be taken off. Suppose that the flyer spindle runs in a direction that will give more twist to the thread, then the thread that forms the inside of the ball will be harder twisted than that on the outside of it; although this peculiarity in the balling machine is a defect, it is so small a one that I do not suppose it has ever been tried to be cured, for if the defect were a great one it could be cured by a little extra mechanism being added to the present machine.

A considerable quantity of thread is put up in balls known by the names "crotchet yarn," "crotchet thread" and "crotchet cotton;" the balls that are made with this kind of thread are much larger than what the sewing thread balls are; this kind of thread is mostly used for fancy work, such as anti-macassars, &c., which are done by the hand.

There is also a soft twisted thread made, which is used for curtains and "tambouring"—that is, sewing figures upon the cloth, not in the process of weaving, but after the cloth is woven; and the quantity used is greatly increased since the improved machinery has been introduced for tambouring purposes.

TWISTED YARNS OF VARIOUS KINDS.

What is meant in this place by "twisted yarns," is a number of plies of yarn twisted together, for all yarns are twisted. There is a number of names given to twisted yarns, and although not known by the name of "thread," the process of twisting them is similar—such as, lace yarn, hosiery yarn, whip, frame thread, double warps, worsted yarns, heddle yarns, &c.

Lace yarn derives its name from the fabrics that it was made into—such as, lace veils, lace collars, &c.; but these articles are not the only things that it is used for; some seasons there is a large demand for it to make the warps of particular kinds of cloth. A few years since, there was a large quantity of lace yarn used for making a cloth known by the name of "grenidine." For this fabric the lace yarn, before it was made into the warp of the web, was very highly

polished, giving it a gloss that the thread retained after it was woven into cloth. There are always some lace warps being used, less or more, according to the demand for the kind of cloth, the warps of which are lace yarn.

Hosiery yarn is the twisted yarn that is used for making stockings, from which it derives its name; "hose" or "socks" meaning covering for the legs. This yarn or thread is also used for making semmets and drawers; it is generally made from the wool got from the sheep, and from cotton yarns; this yarn has less twist than common thread.

The twisted yarn called "whip," is mostly used for forming the flowering that is made on that cloth called lappets; it is made in two and three plies generally, and is sold both in cop and hank; when it is sold in hank it is for the purpose of getting it dyed, for there is a large quantity of coloured whip used; the colours are principally red, orange, green, and blue.

There is a small quantity of thread made use of for sewing little spots or sprigs on cloth, when the cloth is in the process of weaving, done by what is called the "sewing frame." The sewing frame and the embroidering machine are described in the "Art of Weaving."*

* The Theory and Practice of the Art of Weaving. By John Watson, Glasgow: George Watson, 58 & 64 Ingram Street. Cloth 12/6.

Double warps are another sort of twisted yarn; some of these double yarns used for the warps of webs, are not so much twisted as lace yarn, and they are made from cotton, silk, linen, and worsted yarns; some of the worsted kinds are made into warps for damask table-covers, window curtains, and bed hangings, for the superior qualities of these goods.

Another sort of thread known by the name "heddle twine" and "heddle yarn" is largely employed in connection with weaving; the heddles which cause the warp of the web to form the "shed" for the shuttle to pass through, is made of this class of twisted yarn; there is a large variety of heddles, and none of them are made with less than nine plies, and some of the superior sorts have as many as eighteen plies; there are also some used in the mounting of harnesses for figured weaving; when it is employed for this purpose, it is made of linen yarn, being less elastic than either cotton or worsted.

TESTING THE QUALITY.

If really good thread or any other kind of twisted yarn is to be made, the first and most important thing is to have the best yarn to begin with; what may be considered good yarn for some purposes would not do for making good thread. A person who is a

judge of yarns can tell, by looking at them, what is the best, if there is a difference in appearance; but, even a judge, if there are three or four samples submitted to him to give his decision as to which is the best, is at a loss to tell, when the appearance of all the samples are the same; but, although all the samples look equally good, there may be a difference in the strength, and, if so, the sample that stands the most strain is the best yarn.

The mode practised by spinning masters and managers, until recently, for testing the strength of yarn, was this:—He took a single end of the yarn, ten or twelve inches long, and, with the finger and thumb of the left hand, he held one end of it, and the other end he held with the right hand; then placing the left hand down firmly upon a measure (a common two-foot rule or yard measure), he drew the thread with the right hand slowly, so as to observe the exact place that his right thumb was when the yarn broke; the yarn that stretched the greatest distance before breaking was considered the best; this of course proved the elasticity of the yarn, but it did not exactly prove its strength. To prove the strength of it in another way, they would take a skein or hank of yarn, or any other given quantity, hang it up on a hook, then attach another hook to the lower end of the yarn, and weights were hung on to the lower hook until the yarn broke.

The finding of the strength of the yarn with weights hung to it, was rather a clumsy plan, and it has been superseded by small machines made for the purpose of testing the strength of yarn. There are different kinds of these testing machines; those that register the strength of the yarn are better than those which have to be watched until the yarn breaks. Suppose that a spring balance, similar to those used by some butchers and grocers, were taken to test the strength of the yarn, and one end of the yarn to be tested to be fixed to the floor, and the other end to the hook of the spring balance; by pulling the spring balance upwards, it would cause the handle that indicates the weight to move, at the same time indicating, in pounds and ounces, the strain that has been put upon the yarn up to the point of breaking; suppose that the handle that indicates the weight was to remain at the figure it rose to when the yarn broke, it would be in principle the same as the testing machine.

The machines which are made for the purpose of testing the strength of yarn, are of various constructions, but one of the best consists of a sole plate made of cast iron, similar to the bed of a small turning lathe, with two small heads or stands; one of the heads is made fast to the sole plate, the other is movable by a screw similar to what is used in a small screw cutting lathe; there is in the fast head a rod of iron with a rack on the under side of it, and there is

a pinion that gears into this rack, the pinion being made fast on the end of a round arbour; on the other end of the arbour, is fixed the lever with the weight on it; on the end of the rack rod, that points to the shifting head, is a hook, on which the yarn is put; the rod with the rack being movable, when the strain is put upon the yarn, the rod is moved, and the rack turns the pinion which lifts the lever. The lever is in front of a quadrant, and the scale of figures which indicate the weight is marked on the face of the quadrant. The sole plate is also marked in inches and tenths of an inch. The yarn to be tested is hooked on to the rack in the fast head, and also on to the shifting head. When the screw is turned, it pulls the shifting head from the fast head, which tightens the yarn; when the yarn is at its ordinary tightness, a note is taken of the figure, that the shifting head is at, and when the strain is put upon the yarn, it turns the lever of the quadrant up. The person who is testing the yarn keeps turning the screw until the yarn breaks. Upon the arbour which lifts the lever are three small ratchet wheels—each wheel has a catch to keep the lever from falling down when the yarn breaks. The reason for having three ratchet wheels is to give the weight more exactly, for if there were only one wheel, and the yarn breaking, when a tooth was nearly up, the lever would fall down a little; whereas, when there

are three wheels, the chance of the wheel going back is reduced.

When the strain put upon the yarn has been brought up until it breaks it, a note of the weight which it took to break it is taken, and entered in the test book, also the amount of elasticity the yarn gave before it broke, also the size of the yarn. If it is thread that is being tested, the particulars concerning the thread are also entered in the book. Thread is much stronger than common yarn, and will require a greater power to break it; so as the same machine will do for both yarn and thread, there is a separate weight for each, and a scale on the quadrant to suit the different weights.

To find the number of twists on the inch of yarn or thread, there is a small machine for the purpose. It is fixed on the sole plate of the machine for testing the strength of yarn, and consists of two brackets—one for holding the clasps that hold the yarn, the other for supporting the small spindle, which is turned when taking the twist out of the yarn. On the small spindle, between its journals, is fixed a screw or "worm," that gears into a small brass wheel, which has eighty teeth in it. This wheel drives the handle on the dial plate, the dial plate being numbered, tells the number of twists that were in the thread or yarn after the twist has been unwound. Both these machines are very useful for spinners,

weavers, thread makers and yarn merchants, in their different employments.

For linen thread, the finest flax should be selected, to spin the yarn which is to make the thread. There is nothing to complain of for want of length of staple in flax. The great desideratum is to get flax with an evenly fibre, and it is most essential that it should be even for thread making purposes; for, if the flax is taken at random to spin the yarn, it will be too rough to make a good quality of thread.

When the thread is to be made from cotton yarns, the yarn that will stand the greatest strain is in general the best. It is not nearly so difficult to make evenly yarn from cotton as from flax. Very smooth and very evenly yarn can be spun from comparatively short stapled cotton, but it has not the strength that the yarn has which is spun from long stapled cotton; therefore, the thread which is made from yarn spun from Sea Island or good Egyptian cotton is the best, and some spinners make it their special business to spin yarns only for thread making purposes. For some kinds of twisted yarns, the short staple cotton does well enough—such as, for double warps for fabrics that can be woven without putting much strain on the warp threads, also for whip that is used in lappets, and a few others where the expense of the long stapled cotton prevents the manufacturer from using the article that is made from high-priced yarns.

CHAPTER VII.

GENERAL REMARKS

IN CONNECTION WITH

THE ART OF SPINNING AND THREAD MAKING.

A few things will be taken notice of in this chapter which might have been taken into consideration before; but, as they are of a miscellaneous character, I have thought it proper to leave them for this place.

TWISTING YARN FROM A BEAM.

A system has been introduced of late, for making a kind of thread or fine twine, that is sold for various purposes. The yarns that it is made of are spun from either linen, cotton, hemp or jute. Suppose it to be linen yarn that the thread or twine is to be made from; if it is not to be bleached or dyed, the yarn, as it comes from the spinner, is wound upon bobbins suitable for the warping machine, and as

many of those bobbins are put in the bank as will make up the number of ends that are to be warped upon the beam. If there are ninety spindles in the machine that gives the twist to the thread or twine, and if all the spindles are to be employed in producing twine with four plies, then the number of bobbins put into the bank will be four times ninety, or, in all three hundred and sixty bobbins. The yarn is warped on a beam, the length of which is nearly equal to that of the spindle machine. To keep the machine as short as possible, for the number of spindles in it, the spindles are arranged in two or three rows, similar to what they are in the roving frame.

After the beam has been filled with the yarn, it is placed at the back of the spindle frame. The spindle frame is, in some respects, the same in construction as the "fly frame," the difference being that there is no mechanism required to regulate the speed of the bobbins, or to drive them. The bobbins are dragged round with the twine the same as in the throstle frame. The motion for regulating the building of the twine on the bobbins is also the same as it is in the throstle frame. The yarn on the beam is taken through between a pair of rollers, situated at the back of the frame; there is a reed at the back of the rollers that guides the yarn; then there is another pair of rollers at the front of the machine, about

eighteen inches higher up than the top of the flyers. The yarn, when it passes through between the back pair of rollers, is in the form of a web, all arranged in single ends; but, between the two pairs of rollers, there is a reed or ravel, with ninety divisions in it, one for each spindle. Four ends are put through each space in the ravel, and then taken through between the front pair of rollers, and down to the flyers, and round the bobbins.

If the spindles were now made to revolve, it is evident that the four plies of yarn would be twisted together. Seeing that the rollers, between which the yarn passes, has got no wheels or pinions to drive them, or regulate their speed, and, by so doing, regulate the number of twists per inch to be put upon the twine; there must be some other thing to do it. In this frame the twist is regulated by the speed of the warper's beam. The beam with the yarn on it is supported upon a horizontal cylinder, the same as the one in the warping machine, and which gives motion to it. This cylinder is driven by a small shaft from the spindle frame, and when the frame is put in motion so is the cylinder. The spindles revolve at a fixed uniform rate. The cylinder also goes at a uniform rate, but not at a fixed speed, the speed of it being altered to suit the twist to be put on the twine.

Some kinds of twine require very few twists per inch. Suppose a kind that was to have eight twists

on the inch, and that the speed of the spindles is four hundred and eighty revolutions per minute, which is about the right speed for the spindles, that would give sixty inches of twine per minute from each spindle, so a speed will have to be given to the cylinder to suit this length of twine, with eight twists per inch.

It is requisite to have the cylinder as large in diameter as to allow the beam to revolve when empty, without the flanges of it coming into contact with the shaft of the cylinder. To have the proper size of flanges on the beam, they should not be less than twenty inches in diameter, which will give a circumference of fully sixty-two and three-quarter inches.

EXAMPLE No. 1.

```
Diameter of cylinder,  20 inches.
                       22
                       --
                       40
                      40

                  7)440(62 857 circumference of cylinder.
                    42
                    ---
                     20
                     14
                     ---
                      60
                      56
                      ---
                       40
                       35
                       ---
                        50
                        49
                        --
                         1
```

It will be seen, from the calculation, that one revolution of the cylinder in a minute will give more than what is required for the speed of the spindles in one minute. Dividing the number of inches of yarn produced in one minute, by the circumference of the cylinder, the answer will be the number of revolutions the cylinder should make in the same time. We have found the length of yarn to be sixty inches, and the circumference of the cylinder to be fully sixty-two inches.

EXAMPLE No. 2.

Circumference of cylinder, 62 857)60·0000(·95 speed of cylinder.
565713
———
342870
314285
———
28585

The range of pinions in the machine is amply sufficient to vary the speed of the cylinder, to suit any twist that the twine requires. The drag put upon the bobbins keeps the yarn tight between the flyers and the warper's beam, and it is the motion of the yarn that drives the rollers. There is as much friction put upon the beam as will prevent it from being turned faster than the speed of the cylinder; for, if there were nothing to retard the beam, the strain put upon the twine when being twisted, might draw the yarn faster off than the speed of the cylinder gives it.

The operation for twisting coloured twine is the same as that for gray; but there is a difference in preparing for it. The gray yarn is first warped on a beam, in the same manner as when warping for "chains"—that is, when it is for chains, there is a lease cord put in every three or four hundred yards. These cords are put in for the beamer's guidance should any accident occur to the yarn in the process of dyeing or bleaching. When the warper has put the quantity of yarn on the beam, it is taken out of the warping machine and "linked"—that is, the yarn is unwound from the beam, and put up in a bundle, which is called a "chain." This chain is sent to the bleacher or dyer, and, when it is returned, the beamer winds it on to another beam, which is sent to the spindle frame to be twisted into the twine it was prepared for. Suppose the twine is to be made of three plies of yarn—one ply white, one red, and one blue—then there are three chains in the first warping, and when these have been returned from the bleacher and the dyer, they are sent to the beamer, who puts all the three chains on one beam. The beamer lays down the chains on the beaming tables, then takes the lease ends of the chains up to the ravel and reed, and performs the operation called "indenting," which is putting the yarn that composes the three chains into the reed, so that, when being put into the twisting frame, one end of white, one of red, and one

of blue, will come off in regular rotation. Each chain has a table for itself, for the purpose of taking out any twist the chain may happen to receive at the bleacher's or dyer's.

There are more machines for twisting from the beam than the one just noticed. These are used for different things, such as shoe ties, stay laces, &c.

THE MANAGEMENT OF STEAM BOILERS AND ENGINES.

For those who have the charge of the boilers and engines, I will make a few remarks.

There are so many different makes of boilers in use for generating steam, for the purpose of driving the engines and heating the factory, that it is not yet decided which is the best for that purpose. But the kind that is most selected at present for factories are those with a flue, or flues, running longitudinally in the boiler; and, in these flues, the fire-place is fixed. Behind the fire bars in the flue there are three, four, five or six tubes, about six or seven inches in diameter, fixed in the flue. These tubes are arranged so that none of them will be parallel to another. This arrangement is made to allow the flames to impinge upon all the tubes. The more tubes there are in a flue, the more will be the saving

in fuel. This make of boiler is easy to manage, and not very expensive at first.

Some engineers approve of the vertical boiler which is composed of a series of tubes. Their advocates say they take up less room, and that they generate a given quantity of steam in a given time, with less fuel than any other; and, as the diameter of the tubes is comparatively small, they stand a greater pressure than the boilers made in the common way, consequently are less liable to burst.

Whatever kind of boilers may be put in, it is advisable to have them made sufficiently strong to stand a pressure of at least a hundred pounds to the square inch, so as to work with safety at fifty pounds; although fifty pounds, or even thirty, are not required for the purpose of driving the engine, it has been found a saving of fuel to work with high-pressed steam.

At one time it was troublesome to use high-pressed steam for heating the factory, but that is now got over by reducing the pressure in the pipes before it is allowed to go into the mill; a "reducing valve" being placed between the boiler and the building to be heated, serves the purpose most effectually, as the pressure can be regulated to any degree of nicety, merely by shifting a weight upon a lever.

It is very important that the boiler be kept clean. The number of times it should be cleaned, during

one year's working, will depend upon the kind of water made use of. The best water for boilers is that which contains the least amount of foreign matter—such as iron, magnesia, lime, &c., all of which are injurious, by leaving a deposit or incrustation upon the plates of the boilers, not only corroding and weakening them, but also preventing the perfect absorption of the caloric by the water. To remedy this defect, when pure water cannot be profitably obtained, various expedients have been resorted to; but perhaps the best is to have a small cistern below the boiler, and connected to it by a blow-off cock, the frequent use of which will go far to keep the boiler clean, for, every time the water is blown out, a quantity of the deposit will go out with it.

To prevent the radiation of heat from the boilers and the steam pipes connected to them, they ought to be well covered over with some non-conducting substance—such as hair felt. Every boiler should have a water and steam gauge; they are useful to the engineman; besides, the manager can see the state of water and steam in the boiler at a glance. If the proprietor or manager is desirous of seeing the state of the steam and water in the boiler, without going to the boiler-house, he can have the indicator in his private room, by having a small pipe led from the boiler into his room for the steam gauge, and a light chain for the water indicator.

It may appear a little difficult to have the water gauge away from the boiler into another apartment, which may be at a higher level than the boiler itself; but it is very simple. The chain is attached to a float that is in contact with the water in the boiler (the float can be either inside the boiler or in a tube for the purpose outside of it), and, as the float will rise and fall with the water, it will give motion to the chain which causes the indicator to rise or fall in the manager's room. It can be so set that, when the water is either too high or too low in the boiler, it will cause a bell to ring; and, as the manager will have occasion to be frequently out of his room, the bell may be made to ring until he returns, if he is not absent more than five or six hours. How this is accomplished is as follows:—The chain that is attached to the float is conveyed by pulleys from the float to the apartment, and from the floor of the apartment the chain passes up to the ceiling and over a pulley, and at this end of the chain a weight is hung, sufficiently heavy to draw the chain down when the float rises in the boiler. On that part of the chain that passes from the floor to the ceiling, is fixed a rod of iron at right angles to the chain. The rod is four inches long, so that it projects on each side two inches from the centre of the chain. The projections move on the face of a brass plate, which is marked on the face in inches, corresponding to the

water lines in the boiler, which shows the state of the water in the boiler. If at any time the water is allowed to get too low or too high, the iron rod that projects from the chain comes into contact with a catch, and lifts it out of gear from the wheel that drives the apparatus which rings the bell. There is one bell for low water and another for high, so that the manager will see, when he returns to his room, which of the bells, if any, has been acted upon.

If this kind of indicator were more used there would be less risk of the water becoming too low or too high in the boiler, because, the man having charge of it, knowing that he could not conceal his carelessness, would be more attentive to the state of the gauges.

In working with steam at a high-pressure, every care should be taken to prevent explosions. It is true that when steam is risen beyond a given pressure, the surplus will blow off at the safety valve, and although it is seldom that these valves get "stuck," they sometimes do—then a greater force is required to open them than was intended when all is right; therefore, two safety valves is the least that should be put on, which will reduce the risk to a great extent.

The steam gauge will tell the number of pounds of pressure per square inch that is on the boiler. The correctness of the gauge can be ascertained by comparing the actual weight per square inch, that is on

the safety valve, at the point when the steam begins to escape. If the safety valve be five inches in diameter—that is, the surface of it on which the steam acts—the following rule will be found a very simple one:—Multiply the diameter of the valve, which is five inches by five, and the product by the decimal ·7854, and, after taking off the four figures at the right hand, the remainder is the number of square inches in the valve—5 × 5 is 25.

EXAMPLE No. 3.

$$\begin{array}{r} \cdot 7854 \\ 25 \\ \\ 39270 \\ 15708 \\ \hline 19 \cdot 6350 \end{array}$$

The calculation shows that the number of square inches in this valve is fully $19\frac{5}{8}$. Suppose the pressure wanted to be thirty-five pounds to the square inch, then the $19\frac{5}{8}$ multiplied by 35 will give the gross weight to be put upon the valve.

EXAMPLE No. 4.

Number of square inches,	19·6350
Number of pounds on one inch,	35
	981750
	589050
	687·2250 gross weight.

The whole weight for the valve is six hundred and eighty-seven pounds; if the weight can be con-

veniently put upon the valve, without a lever, it is safer; being more simple, it is not so likely to go wrong as with the lever.

STEAM ENGINE.

It will depend upon the size of the factory, and the kind of machinery that is in it, what power will be required. If the greater part of the machinery be of the throstle frame kind, a greater quantity of power will be required than would be if it were all spinning mules. But, if the power needed is more than fifteen horse-power, it is better to have two engines, as the motion will be more regular and steady, which is an essential thing for spinning. The advantage in using two engines, besides the regular motion, is that less fuel is required to drive the machinery. The two engines are connected in such a manner that, when the one has no power, the other will have its greatest power. The steam is put into the first cylinder at a high-pressure. When the steam has done its work in the first engine, it enters the cylinder of the second; the cylinder of the second engine having a capacity at least five times larger than the cylinder of the first, the steam is allowed to expand, so that the pressure will be only as one to five; but, as this cylinder is connected to a condenser, the piston receives the

advantage of the vacuum, whatever that may be. If the steam, when it enters the second cylinder, has a pressure of five pounds to the square inch, and the pressure of the atmosphere has been removed in the condenser to the extent of twelve pounds to the square inch, (this is called twelve pounds vacuum), then the twelve added to the five pounds of steam, will give a pressure of seventeen pounds on every square inch, on the piston of the second cylinder.

By using the steam for driving the engines, and by having them connected as described above, very little of the steam is lost, and the power expended on driving a fly-wheel, sufficiently heavy to keep the motion regular in a single engine, is saved. But, whether the high pressure engines by themselves, or the high pressure and the condensing engines combined, is the more economical for driving mills, has not yet been sufficiently tested to be decided. Where water is scarce, and a high price paid for it, the high pressure engine is preferred.

It is also not yet decided, whether it is better to have a number of small engines distributed through the factory, such as one for each flat, or to have only one pair of large engines to drive the whole. By having only one pair, a greater amount of shafting is required to convey the power to all the different places in the factory, than what is necessary when small engines are employed.

Whatever kind or number of engines are employed, all the working parts in connection with them should be regularly cleaned and oiled. The large journals should have self-acting oil cups, which will save both time and oil. A steam gauge, also a vacuum one, should be fixed in some conspicuous place, near the engines, to show the working state of the engines.

To give the manager or proprietor an opportunity of seeing the number of strokes the engines make in one hour, day, or week, an indicator for that purpose should be connected to the engines. This indicator should be one of those that will show what day, and the hour of that day, the engines have been below or above their regular speed. If any accident happens that would allow the engines to run far beyond their regular speed, there is a danger of something being broken, and, to prevent this, the governor should be so constructed that it will shut off the steam entirely. Few engines have this kind of governor, but it is better that breakages should be prevented; therefore, it is advisable for the proprietor to take advantage of this kind of governor. It is also requisite at different times to see how the engines are working, by applying the indicator, by which a diagram can be taken, showing the pressure upon the piston, at the different stages of its progress in the cylinder. This diagram will enable the engineer to see if the valves are working properly; for, although the valves are pro-

perly set when the engine is put up, many things might occur to put them wrong in the course of working. It has frequently happened that some insignificant thing has gone wrong, which could not be easily seen, and thus the engine has been forced on by a greater pressure of steam for days, before the fault has been found out; whereas, if the indicator had been applied, and a diagram taken, the fault would at once have been detected, and a remedy applied, which would have saved all the extra expense for fuel, in forcing up the steam, to keep the engine at its proper speed.

THE EFFECTIVE POWER OF THE ENGINE.

It is desirable that the proprietor or manager should be able to test the working power of the engine, which is easily done when the principles upon which it is tested are understood. The power of the engine is estimated by that of so many "horses." The nominal horse-power is according to the diameter of the cylinder, but the real power is according to what it is able to drive, and the effective power is what it *is really driving.* If three engines were made with the same diameter of cylinder, say each fifty horse-power (nominal), from circumstances connected with the manner of working them, one of them—

which we will call No. 1—might not be able to drive more than twenty-five horse-power "real," or what is called "indicated horse-power." The second engine, or No. 2, is able to drive fifty horse-power, but no more, so that the "real," or "indicated," and the "nomimal" power of No. 2 are the same. The third engine, or No. 3, may be driving a hundred indicated horse-power, doing, in reality, four times as much work as No. 1, and two times more than No. 2. The three engines may all have been made by the same engineer, and taken off the same patterns, there being—so far as the engines are concerned—no difference; the difference lying in the way in which they are driven, and how the steam is applied to the cylinder.

At the time when steam engines were being introduced to supersede horses for driving machinery, the work they performed was said to be equal to that done by so many horses, and Watt fixed the power of the horse to be equal to 33,000 lbs. raised one foot high in one minute, and this has been adopted as "one horse-power." The number of feet that the piston should travel in one minute was also fixed at two hundred and twenty feet (according to some, two hundred and forty), and from this, with the pressure on the piston, the nominal horse-power was established, which, in a condensing engine, is from twenty to twenty-two square inches of area in the piston.

This will be better understood on examining the following calculations.

We will take for illustration a cylinder of thirty inches in diameter, and five feet long—that is, a five-feet stroke. Multiply the diameter of the piston by its diameter, and the product by the decimal figures ·7854 for square inches.

EXAMPLE No. 5.

```
Diameter of cylinder, 30  inches.
                      30
                    ----
                     900
                   ·7854
                   -----
                    3600
                   4500
                  7200
                 6300

                 706·8600  square inches in piston.
```

The number of square inches in the piston is 706·8600; this, divided by 21, will give the nominal horse-power of an engine with a thirty-inch cylinder.

EXAMPLE No. 6.

```
Square inches, 21)706·8600(33·6600 nominal horse-power.
                  63
                  --
                   76
                   63
                  ---
                  138
                  126
                  ---
                  126
                  126
```

This shows that an engine, with a piston thirty inches in diameter, is $33\frac{2}{3}$ "nomimal" horse-power; and, when an order is given to an engineer for a condensing engine of thirty-three horse-power, he should give one with a piston nearly thirty inches in diameter.

Let us now see what *real* power this engine will give with an average pressure on the piston of twelve pounds, including both the steam and vacuum. There is, within a small fraction, 707 square inches in the area of the piston; this, multiplied by the twelve pounds of pressure, will give the whole weight on the piston. We will take the speed of the piston at two hundred and twenty feet per minute, which is about the old speed.

EXAMPLE No. 7.

	707	square inches in piston.
Pressure per inch,	12	pounds.
	8484	whole pressure on piston.
	220	feet, speed of piston.
	169680	
	16968	
33000)	1866480(56·56	power of engine.
	165000	
	216480	
	198000	
	184800	
	165000	
	198000	
	198000	

The foregoing calculation shows that the force exerted upon the piston, with twelve pounds of pressure to the square inch, is equal to fully fifty-six and a-half horse-power, and that is not near the real power that can be taken out of an engine with a thirty-inch cylinder. This will be seen from the next example, when a different pressure and speed are applied.

EXAMPLE No. 8.

```
                      707  square inches in piston.
Pressure per inch,     18  pounds.
                   ------
                     5656
                     707
                   ------
                    12726
Speed of piston,      360  feet per minute.
                   ------
                   763560
                   38178

          33,000)4581360(138,829 horse-power.
                 33000
                 ------
                 128136
                  99000
                  ------
                  291360
                  264000
                  ------
                   273600
                   264000
                   ------
                     96000
                     66000
                    ------
                    300000
                    297000
                    ------
                      3000
```

In this last example an average pressure of eighteen pounds to the square inch is the power exerted upon the piston, and instead of the engine running at twenty-two strokes per minute, it is making thirty-six strokes; the cylinder being five feet long, that number of strokes gives a speed to the piston of 360 feet per minute. Neither the pressure nor the speed given in this example are up to the highest point at which some engines work, yet, in this case, the nominal engine of thirty-three horse-power, is really working at one hundred and thirty-eight horse-power.

When testing an engine with an indicator, the paper for receiving the pencil mark, or what is called a "diagram," is divided into so many divisions, whatever may be the length of cylinder. A very common number is *ten*, but that is a matter of choice; of course, the more divisions, the more accurate will be the test—in most cases ten are sufficient. The pressure of steam is marked in each division of the paper on one side, and the vacuum on the other. These are added up and divided by *ten*, which gives the average for the whole length of. the stroke. Suppose the steam pressure is eight pounds, and the vacuum is equal to ten pounds, then the whole pressure on the piston is eighteen pounds, so that the number of square inches multiplied by eighteen, and the product by the speed of the piston, will give the power that is

exerted by the engine; but that does not tell the effective power of the engine.

To ascertain the real work the engine is performing, the indicator is applied, and a diagram is taken when no machinery is being driven. This diagram will show how much pressure is required to drive the engine itself, and that will require to be deducted from the amount given by the diagram when all the machinery is in operation. By this means, it can be ascertained what power is required for each, so much for the engine, so much for the engine and gearing, and so much for the engine, gearing and whole machinery, or any quantity of it. In taking the diagrams to find the power required for the different parts of the work, it is requisite that the speed of the engine, and the pressure of steam in the boiler, be the same at all the different trials.

The effective power of an engine is the power given out to drive anything more than itself. Sometimes a great quantity of the power is consumed in driving the shafting that conveys the power from the engine to the machines, but that is requisite, and is called *effective power* as well as the power taken to drive the machines in the factory. After it is known exactly what power is required to drive the engine itself, where everything about it is in the best order, it is easy to find from a diagram if anything goes wrong with the valves, eccentric or anything else, which pre-

vents the steam from acting properly. The vacuum side of the diagram will show if there is anything wrong with the air-pump, the condenser, or anything else connected with it, which would have the effect of lessening the vacuum.

VARIOUS MACHINES.

There has been a number of different machines employed in the spinning trade, but the majority of these are now out of use. At one time a machine was used for reducing the sliver after it came from the drawing frame, which was known by the name "can frame." This machine in its construction as regards the rollers was like the fly frame which is used for making slub or coarse rovings. As they came from the drawing frame the cans were placed at the back of the can frame, in a position similar to that which they occupy in the slubbing frame; and for each can at the back, there was, at the front of the frame, a revolving can, into which the sliver was delivered. This revolving can was made like a tin cylinder, with a journal at one end, and a pivot or step at the other. The revolving cans were placed perpendicular with the journals at the top. The journals were made hollow by a hole being bored down through the centre. After it was reduced by

the rollers to the size wanted, the sliver passed down and through the hollow journals into the tin cylinders. A band pulley was fixed on the gudgeon that was on the bottom end of the cylinder, one for each cylinder; and a tin cylinder, which extended from one end of the frame to the other, drove the upright cylinders. The centre of the top journal was in the same position, in regard to the rollers, as the eye of the flyer in the roving frame.

The operation of this machine was as follows:—The cotton was put through the rollers in the same way as it is in the fly frame, and, when it was delivered from the rollers, it passed down through the centre of the top journal; and as the cylinder was revolving at the same time as the rollers were delivering the cotton in the form of a fine sliver, it received twist in proportion to the speed of the cylinders or "cans." The twist given was no more than just to give it sufficient cohesion to withstand the strain it had to undergo at the winding and stretching machines. After the revolving can was filled with the "slub," it was taken out by opening a door which was in the side of the can, and taken to the person that was to wind it on to large bobbins.

SLUB WINDING MACHINE.

The machine that was used for winding the slub, after it came from the "can frame," was very simple, consisting of two stands with a cylinder made of wood about twelve inches in diameter, and as long as the bobbin between its flanges. The bobbin was placed on the top of the wooden cylinder, and was guided by a skewer, which went through the centre of it. The weight of the bobbin was sufficient to give friction to cause it to be turned round by the cylinder. When the slub is taken from the can, it is in form the shape of the inside of the can, and all coiled round by the motion of the tin cylinder at the time that the slub was being twisted. This coil of slub was put on the floor behind the winding cylinder, and the winder, with her hand, guided the slub when it was being wound upon the bobbin. Only one bobbin could be filled at a time. In this state the slub was very easily hurt, and the workers had to handle it in the most cautious manner. When the bobbins were filled with the slub they were taken to the "stretching frame."

STRETCHING FRAME.

This machine was at one time largely employed in the cotton spinning trade, but is now almost, if not

altogether, out of use. It has been superseded by the fly frame. Its use was the making of rove—it was used for nothing which could warrant the name "stretching frame." It stretches neither the slub nor rove, the slub being drawn with the rollers in the same manner as in the fly frame. However, at one time, before rollers were introduced, a machine somewhat similar to the old spinning jenny might have been used for stretching the rowans, to make them suitable for rove.

The construction of the stretching frame is, in all respects, the same as the mule jenny that is used for spinning coarse numbers—that is, the spindles are set at a greater distance apart; also, the spindles are larger than in the common mule. The large bobbins with the slub are placed in the creel, and the slub is taken and entered into the rollers, the same as the rove in the mule. The rollers reduce it to the size wanted for the *rove*, and the requisite amount of twist is given to the rove as the carriage recedes from the rollers. Whenever the carriage is full out, the spindles cease revolving, and no more twist is given to the *rove*; this part of the operation being unlike that of the mule, because, the spindles in the mule continue, in most cases, to revolve after the carriage is full out. First-rate rove was made with the stretching machine. All the improvements made in other machines for making rove have been in the

direction of cheapening the production, not for improving the quality. One defect often occurred with the slub that was used in the stretching frame, it was this: The slub being so tender, when taken from the can frame, it was frequently hurt before it was put in the stretching frame, in the carrying and winding of it.

To prevent the slub from being damaged in transmission from the can to the stretching frame, a plan was adopted, which, to a great extent, did away with the cause, and which saved the slub from being hurt in the carriage, it was this: A separate tin can was put inside the revolving can, filling it exactly, and the slub when delivered from the rollers went into the inside can, and, when full, the can with the slub was taken to the stretching frame, which saved the winding of it on to the bobbins. After this inside can was introduced, some spinners, who spun nothing but the coarsest numbers, did away with the stretching frame altogether, by taking the cans to the back of the mule, and the yarn was spun direct from the slub without incurring the expense of making it into rove.

TUBE FRAME.

This machine, from the great quantity it could put through in a given time, was largely patronized

it was brought out, and it is still used, although it is not so popular now as at one time. The peculiarity of the tube frame is that it gives a great amount of twist to the rove, and then takes it all out again, before it is wound upon the spools. The machine is made with the balls of the rollers so far apart from each other that, from the centre of the one ball, to the centre of the other, the distance must, at least, be equal to the length of the spool that is to be used and one inch more. This is rendered necessary by the construction of the machine, the spools all lying horizontally lengthwise of the frame.

For each spool there is a small hollow tube, made of cast-iron (it is from this tube the machine gets its name). The tubes are placed in the frame at right angles to the spools, and the part of the tubes that comes in contact with the belt, which gives motion to the tubes, is fully one inch in diameter. There is only one belt for driving all the tubes in the frame, which extends from one end of the frame to the other, and runs at a speed about two thousand two hundred feet per minute, which gives about eight thousand revolutions per minute to the tubes, which gives a very hard twist to the slub or rove between the rollers and the tubes. The tubes were about eight or ten inches distant from the rollers, and the slub was entered into the hollow of the tube, and through it, until it was within one inch of the opposite end, when it came out

at a small hole or eye in the side of the tube, then in through another eye into the hollow in the centre of the tube; it was in consequence of the rove going out and in at these eyes that the tube got a hold of the rove to communicate the twist to it; but when the rove came out of the tube at the end next the spool all the twist was taken out of it.

The tube frame takes up a large space, compared to the number of spools that can be put in it, and, when they are increased in length beyond a certain number of tubes, the power required to drive them becomes very great in proportion to the number of tubes, which is an objection to tube frames, besides the want of twist in the rove or slub; so that the fly frame for the making of either slub or rove is preferred.

Another frame for making rove, which was somewhat similar in its operations to the tube frame, was introduced a short time after it, and was known by the name "eclipse roving frame." The principal difference between the two machines was, instead of the revolving tubes to give twist to the rove, there were two endless belts running in contrary directions, and the rove, as it descended from the rollers, passed through between these endless belts, which gave the rove a very hard twist between the rollers and the belts; but it was all taken out before the rove was wound upon the spool. There were the necessary appliances for keeping the belts close, so that they

would take hold of the rove to give it the twist, also to build the rove regularly on the spools.

The eclipse roving frame was an American invention, and, after it was brought into England, the mechanism of it was greatly improved; but, like the tube frame, after a few years trial it lost its popularity.

THROSTLE FRAMES.

There has been a number of spinning machines which have received the name of "throstle." It has been noticed before that Arkwright's spinning machine, although it received the name "water frame," was really the original throstle frame, because, the machine called the "throstle," is just the water frame simplified in its construction. Both frames have already been taken notice of, and we will now make a few remarks about some of the others.

One machine was brought out that caused a great deal of attention to be paid to it for about two or three years; it was known by the name "Glasgow patent throstle." The difference between this machine and the old throstle lay in the plan for steadying the spindle and flyer, so as to enable the machines to be driven at a greater speed than the old throstle. This was accomplished, for the flyers could be driven at fifteen hundred revolutions per minute more than

what could be obtained by the common throstle. That was the reason of the "Glasgow patent throstle" drawing the attention of spinners to watch its progress; for if there had been nothing to counterbalance the advantage gained by this great speed, it would have been a very great improvement over the other machines.

The construction of this throstle was the same in all respects as the common one, except the spindles and flyers. The legs of the flyer were made about double the length of the legs in the common flyer, and were riveted to a circular plate at the bottom, and this circular plate was made fast to the wharve which drove the flyer. The neck or top of the flyer ran in a bush, and it was this bush that kept the flyer from vibrating when it was driven at a great speed. Indeed, it was the steadying of the flyer, to prevent vibration, that constituted the whole improvement in the "Glasgow patent throstle."

The spindle did not revolve, the under end of it being made fast to the traverse rail. There was a piece of the spindle at the upper end made to suit the hole in the bobbin, on which the bobbin ran when the machine was in the act of spinning. When the traverse rail moved up and down, the spindle and bobbin moved with it; the spindle passed up through the circular plate and wharve at the bottom of the flyer. It was this upper part of the spindle which

acted as a guide for the bottom part of the flyer, and on which the flyer ran. The flyer was made to revolve with a band in the usual way; the yarn as it descended from the front roller, passed through the hole in the neck of the flyer, down to an eye in the leg of it, and this eye guided the yarn on to the bobbin in the same way as in the common throstle, with this difference that the eye was placed in the centre of the leg, instead of it being at the extreme end of it. The revolving of the flyer put the twist upon the yarn, and it was wound upon the bobbin as in the common throstle, by friction being put on the bottom of the bobbin.

The great speed at which this flyer was capable of being driven, promised to be an advantage to the trade; but, after it was extensively tried, the following defects were found:—The spinner could not attend to as large a number of spindles as in the common throstle, in consequence of being obliged to draw up the end from the bobbin, through the neck of the flyer with a hook, occupying nearly double the time. A greater quantity of power was required to drive them, in consequence of the extra friction caused by the neck of the flyer; of course, the greater the speed is, the more power is required; but it was found that it took a greater quantity of power for the same speed in this frame. Being heavy to drive, there was more expense for banding; also for oil; owing to the con-

struction of the spindle and flyer the machine cost more at first; so that the advantage gained by the speed was lost in the other things which we have noticed, and it went out of use.

Another spinning machine known by the name "Danforth throstle," was much in vogue at one time. It is an American invention, and was introduced to this country upwards of forty years ago. The speed at which it could be driven attracted the attention of those interested in the spinning business. It had a fixed spindle, on the top of which was placed a hollow cone. The wharve which drove the bobbin was loose on the fixed spindle. The bobbin, resting on the wharve and being attached to it, was driven at the same speed as the wharve, and it was this revolving motion of the bobbin that gave the twist to the yarn. The bobbin carried the yarn round with it, and, of course, every revolution of the bobbin gave one twist to the yarn, less the amount of speed that was necessary to wind the yarn on the bobbin.

If the speed of the wharve and bobbin was six thousand revolutions per minute, and the rollers were delivering two hundred and eighty inches of yarn per minute, this yarn would require to be wound upon the bobbin in the same time, which would cause about ninety revolutions of the bobbin to be lost out of the six thousand in giving twist to the yarn; because the yarn was wound on the bobbin by it

being retarded by the under edge of the cone. The wharve and the bobbin were made to ascend and descend by a motion similar to the one used for the traverse rail in the common throstle.

The "Danforth throstle," like the Glasgow patent throstle, required a large amount of power to drive it, and it also had other drawbacks to counterbalance the advantage of the great speed that it could be driven at; and, after a few years' trial, it lost its popularity, and very few were ordered by spinners putting in new machinery.

At pages 209 and 242 I have made some remarks about improvements in spinning. To any one wishing to know how the details are to be carried out, the Author is prepared to give the information.

THE END.

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